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SPECIAL METHOD
IN ELEMENTARY SCIENCE

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IN

ELEMENTARY SCIENCE

FOR THE COMMON SCHOOL

BY

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PREFACE

THIS volume is a complete revision of the "Special Method in Science" first published in 1896. It is also extended to include the entire course of the elementary school. The plan is to give a broad view of the problem of science teaching by a brief historical and critical survey of elementary science work and of the ideas thus far developed in schools.

The discussion passes from general aims to specific plans for the course of study and method of instruction. A few illustrations are also given of a full treatment of topics.

One of the greatest difficulties is to find some basis for selecting and arranging the most important and suitable topics for a course of study, where the field of science furnishes such a vast and varied collection of materials.

We have also undertaken the difficult problem of combining the usual nature study topics with a great series of studies based upon the practical applications of science to life. So far as this is successful,

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SPECIAL METHOD IN ELEMENTARY SCIENCE

CHAPTER I

INTRODUCTORY DISCUSSION

For at least three centuries there has been abundant discourse among writers on education in favor of natural science study in the schools. Educational reformers like Comenius, Rousseau, and Colonel Parker have laid great stress upon the educative value in childhood and youth of the contact between mind and matter in the forms which nature presents. School education has always been too bookish, too much separated from objects and realities of experience.

Comenius found education in his day mired in Latin forms, technicalities, and abstractions. It was a killing process to try to awaken childlike interests and mind action upon the dead rules and inflections of a purely formal grammar, and that in a foreign tongue. By means of his "Orbis Pictus" and other books of method he tried to infuse some degree of interest and meaning into the lifeless drills of the schools. But it was an almost hopeless task so long

as Latin remained, like a vast breastwork of obstruction, at the very doorway of education. It was impossible to establish a rational system of popular education so long as a dead language stretched its lifeless body across the threshold of school life, barring entrance to the fields Elysian. But thanks to the power and vigor of our native tongue, it has taken at last the supreme place among languages in a child's education, and when he first enters school he is in possession of this treasure. The same thing has happened in France and Germany and in other European countries.

The vernacular has become the fundamental medium of thought. One of the enormities, therefore, that vexed the souls of children two or three hundred years ago has been swept away. But the linguistic and verbal spirit of the old régime is still with us, and many teachers still think children have the ideas when they have only conned the forms in which ideas are expressed. In the days of Latin supremacy, Comenius and the other reformers tried to save instruction from empty verbalism by associating the objects in nature with the Latin names, and we have been trying, for more than one generation, by means of object lessons and nature studies, to redeem education from the dry rot of verbal memorizing. But in our day we have already got beyond the idea that natural science is simply an auxiliary, a means of making language and other studies more

significant and real. Nature study stands out in its own right, an equal among such studies as reading, mathematics, and language.

It is a matter of no little surprise with many that nature study has made so small progress in the common schools. For three centuries in Europe and America there has been constant advocacy and boundless faith and enthusiasm in nature studies for children, but the output in the schools is close up to nothing. Yet a fuller appreciation of the inherent difficulties involved in a deep educational problem like this shows that centuries rather than years are required in working it out. It may be truly said that a right selection of topics and a right teaching of natural science would produce a marked change in the teaching of all subjects in the common school. The method of realism in science subjects is a good criterion of method in all studies. A proper attitude of a teacher in handling science topics in a class is a direct protest against a large part of the work in all studies now done in our schools.

We talk about science teaching, realism, sense training, experimental work, investigation, field work, etc., and still we hug our books as tightly as before. If we were dropped into a school of eighty children without books or paper, as was Pestalozzi at Stanz, we might be helpless. True science teaching is the direct realism of education. In nearly all other studies we can get along with books and deceive

ourselves, more or less, with words. But in introducing children to nature studies the absurdity of mere book-work is more apparent than in other branches of learning. In natural science, therefore, more than in any other study, we are forced to find the true method of object study. We are dealing with those objects and phenomena which stimulate the mind to its fundamental activities and supply it with elementary material of thought. Nature study furnishes the constructive materials and illustrations out of which other studies explain and make real their notions. In its own right, nature study is the direct acquaintance-making and examination of these objects at first hand. It is, therefore, the true parent of all realism in studies (realism used in the sense of object study). In contrast to this we see an oppressive verbalism still prevailing in the schools, and the heaving of general notions to the front in most text-books and recitations. The movement from particular to general, from percept to concept (general notion) is not yet recognized as the primary law of learning. It is strange that nature study with its objective realism is not yet come into possession of its rightful patrimony. Nature study, more perhaps than any other branch of learning, advertises the foolishness of forcing upon a child the general notions, the principles, before the illustrative materials have been presented to his mind.

The world of nature is the chosen domain of a

child's operations; it is the field of his enterprise, of his efforts at self-expression. Nature holds out objective inducements and invites him to varied effort. Even if the stimulus comes from literature, as from myth or historical story, the place for actualizing his ideas is in his physical environment. Robinson Crusoe, for example, is the starter for a variety of experiments and investigations upon the dogs, parrots, grain fields, clay, and other animate and inanimate objects in his own physical surroundings. This is the way in which all historical and literary works should be studied in the schools, with feet upon the ground though the eyes be turned to the stars.

We find, therefore, that the effort to discover the best materials and methods of science teaching will bring us face to face with the broader and deeper problems of the school course. Science teaching has a direct word of warning and of helpfulness to all the other studies. It speaks also to the heart of a child as well as to his senses in all his earlier years. Its place, therefore, in the child's life and in the school curriculum is one of no mean or secondary rank.

Nature study includes the whole broad territory of the physical universe. In order to make the notion explicit, we speak analytically of the natural sciences, — botany, geology, zoölogy, physics, chemistry, physical geography, astronomy, meteorology, physiology. But this list is simply explanatory to older people.

From the standpoint of pedagogy, nature study is not a collection of sciences, nor a scientific unity of all sciences in one, but a practical grasp of the whole physical world around us as a set of conditions environing a child. The best way to look at nature is to recognize it as a body of educative materials, pressing upon the children from all sides, calling out their activities, and impressively iterating the simplest real lessons. There are two phases of artificiality in science teaching which we wish to avoid in the early work with children, though both are indispensable as we advance into higher grades. One is the notion of scientific classification, which to mature minds is identical with any notion of science; and the other, the use of books in science studies. Nature, as she thrusts herself upon the attention of children, is neither classified nor bookish. Nature shows herself as an interesting collection of physical realities, and it is only little by little that children discover and recognize the threads of system running through these objects and activities, and that books appear at all helpful in getting at the explanation of things.

CHAPTER II

HISTORY AND AIM OF SCIENCE TEACHING

If we inquire among thoughtful instructors in science what the purpose of this study is, we shall get a variety of answers, somewhat as follows: —

The training of children to observe closely and accurately so as to form habits of scrutiny results in the sharpening of the senses to acuteness and vigor. It includes, also, the storage of elementary percepts of strictly experimental type. We deal with those objects and phenomena which stimulate the mind to its fundamental activities and supply it with the elementary materials of thought. Nature study leads also to thoughtfulness and the exercise of reason upon the materials presented. It arouses and feeds the spirit of inquisitiveness and investigation. It not only awakens an interest in the causal relations of nature's work, but teaches respect for the law-abiding quality and truthfulness in nature, as grounded in the realism of experimental knowledge. Nature study is also directly useful for its deepening and extension of practical knowledge, as in the lessons of health, temperance, and sanitation. It reveals the utilities of natural products and the

inventions and processes of man's ingenuity as embodied in telescopes, microscopes, steam-engines, medicines, ventilation, photography, mirrors, the compass, pumps, etc. Without a real knowledge of these things, children and grown people cannot adapt themselves to the physical conditions and necessities which their own bodies and the objective world around them impose.

Nature study leads up gradually to a grasp of scientific classifications, of the systematic order and law that prevail in the world; in short, ultimately, to a perception of the plan and wisdom that pervade nature. Here we are upon the threshold of religion. The æsthetic interests and tastes cultivated by nature study, the perception of beauty and grandeur and harmony, are among the strongest educative influences of science study. Some even claim that nature is essentially moral in its teaching, and we may all agree, at least, that indirectly many moral qualities are strengthened by a wise method of science study.

By an inquiry into the history and present status of nature study in the grades we shall find that all these ideas have their influence with teachers, one person laying stress upon one phase of science training, another upon some other. Not only so, but there has been a decided evolution and progress in ideas of method in connection with science instruction in the grades.

The following brief historical view of the successive ideas that have influenced science teaching is suggested by Dr. W. Rein's discussion of natural science in the Fourth School Year ("Das Vierte Schuljahr").

In taking up nature study in the common schools, the first idea to make itself practically operative with teachers and book-makers was the notion of the *wonderful*. Curious or remarkable plants or animals were talked of or read about. Teachers presented children with something marvellous or prodigious in nature to excite their curiosity. Things even freakish or outlandish were called in to satisfy this thirst for the marvellous. Quite a number of the elementary science books now in use in our schools are mainly devoted to a description of such curiosities in nature as the big trees of California, Mammoth Cave, the ant-eater, an elephant hunt, the duckbill of Australia, an iceberg, a geyser. This primitive impulse to feast on foreign wonders and curiosities is contrary to two of the most important requirements of good science study, — first, that the objects studied be taken from the home neighborhood, as the house cat, the dandelion, the maple tree, the butterfly, and other objects already familiar to the observation and experience of children; and second, that children learn to see wonders in the commonest objects, instead of going to the world's end to find strange things. Such study of foreign wonders can

be made only through books, pictures, and verbal descriptions, while true science teaching throws books aside and shows children how to look nature directly in the face. It is a curious fact that this first impulse to seek extraordinary and freakish things in nature is the exact opposite of the true method of nature study. The whole tendency of this perversion of method is to put our trust in books rather than in our own powers of observation, and to cause children to disregard the marvellous things all about them in nature, and to chase the world over on imaginary journeys in the search for curiosities. It teaches dependence upon books and hearsay, and even upon what is mythical, instead of personal observation and direct experience. It turns the mind away from surrounding realities toward distant uncertainties. Yet the impulse to find out the wonderful in nature is legitimate and inspiring, and is one of the strongest motives in nature study. Only let it begin at home with familiar objects, and rest upon the undoubted realities and wonders which every child can find for himself at his own doorway.

The second idea which early showed itself in science studies was the doctrine of *utility*, the practical value and information contained in this study for the average man or child. It is certainly worth while to know the useful and hurtful things in nature. The study of plants and trees brings out medicinal or poisonous qualities. Some animals and

plants are of daily use to men for food or clothing or shelter. Some of the simpler lessons of physics, chemistry, and physiology have to do with comfort and health, while the common inventions and machines in general use in our homes, fields, and factories need to be explained in science lessons. This notion of the utility of science studies has a wide range of meanings, from the low mercenary motive of personal gain, up through all the steps of practical benefit, to the highest utilities which nature has to offer in her service to man. One of the most striking characteristics of the physical world in which we live is the multiplex utility of natural science in the affairs of all classes of people in all their daily concerns. So far as there is progress in the world, men are everywhere seeking to understand and to utilize nature; and it is one of the great problems of education to prepare children for real life by securing to them such an understanding and mastery of the physical conditions of life and of the many and varied utilities in nature. In the early history of science teaching, however, the utility of nature study was thought of in a narrow and illiberal sense. The poisonous and the useful plants and animals marked the limits of the study.

In the third place, a significant and fruitful notion of science came to notice when teachers asked the question, What mental *discipline* is supplied by these studies? Rising above the bare question of utility,

teachers inquired what mental habits and tendencies science studies fostered. Most science teachers to-day lay the chief stress upon the mental discipline afforded by science, that is, the training of the observing powers of children, the quickening of the sense perceptions, learning to see and hear and take more accurate note of the things seen and heard, the habits formed of observing, comparing, and tracing relations, the respect for law and order and truthfulness impressed by such realities. All these are doubly emphasized by science teachers of our day. Perhaps no other idea has been so much exalted by science teachers as this peculiar mental discipline which, it is claimed, is not furnished by other studies. Stated in the above form, this aim is comprehensive and stimulating, but when reduced to the practice of the schools, it often runs into serious error and difficulty. The test for all such drill exercises, which aim at discipline and habit of observation, is the power to *describe* the objects seen and compared. Description becomes a mania. In order to carry this observation drill into school a variety of natural objects is examined and described as to form and appearance, color, quality, and materials. Trees, plants, and flowers, birds and insects, crystals and minerals, are drawn into this descriptive process which easily degenerates into a smooth rut. Every tree is analyzed into roots, stem, and leaves, every flower into calyx, corolla, stamens, and pistils, every leaf

into ribs, veins, and margins, etc., through all the round of nature objects. Such descriptive work may easily grow into a barren detail of external form and feature. The spirit of science teaching drops out, and only the empty form which is supposed to produce discipline remains.

A special advantage reputed to spring from this descriptive drill is *language training*. But science is too important to be made simply a handmaid of language exercises. In fact, if lessons fail as science lessons, they will doubly fail as language. Training children, therefore, to observe and describe is not the leading aim of science study. Its tendency is so strong in the direction of formalism and superficial study of objects that it soon loses all power to stimulate effort. It does not lay hold of the deeper impulses, the wide-awake interest, and stronger effort of children to trace out causal relations, to discover the hidden law, to explain, for example, the construction and use of different organs in plants and animals. In spite of the emphasis placed by the scientists themselves upon this disciplinary value of studies, in spite of the strong necessity for right habits of observation, the mere discipline derived cannot be regarded as the controlling aim of these studies. The real purpose of science teaching in its higher influence is not bare mental discipline, but the permanent awakening of the whole mind and spirit of the child so as to bring him into intelligent relation

to the world around him. Discipline, therefore, is one of the secondary or incidental aims of science instruction.

In the progress of science teaching in the schools a fourth and more comprehensive aim has been set up and put into practice. It is the idea of *scientific order* and *classification*, the reduction of all the varied objects and phenomena of nature to an accurate system of classes and subclasses, of general and special laws. It is an effort to get the mastery of nature by reducing its endless variety of forms and phenomena to system and law. Dr. Rein says: "In the latter half of the last (eighteenth) century lived the great founder or reformer of systematic natural science, Karl von Linnæus. His influence reached far into the nineteenth century and was universal. Goethe himself affirms that, next to Shakespeare and Spinoza, Linnæus exercised the greatest influence upon him. Through Linnæus, system came to the highest renown. In the effort to set up a system which would satisfy all requirements was recognized the highest aim of scientific natural science. In quick succession followed the systems of many scientists. Is it any wonder that system, even down to the common schools, became the chief aim of natural science instruction? Moreover, the pursuit of this aim seems to satisfy an inevitable need, that of bringing knowledge into order, by means of order to get a survey of the multiplicity (die Vielheit) of single

things. For without a principle of order this multiplicity would become an unbearable load." ("Das Vierte Schuljahr," p. 115.)

The drift toward scientific classification or system has been very strong with us, especially in high schools and colleges, where most teachers are trained. In the study of botany, for example, the chief effort was directed to analysis and determination of specimens. When this process had gone on long enough to secure a superficial grasp of all the important classes of plants the chief result was attained. The zoölogies, a few years ago, contained a full classification and brief description of the leading families and orders of the animal kingdom. The text-books in physics and chemistry also gave a brief outline of those sciences. In all these cases the text-book played the principal rôle, and the true scientific method of experiment remained unrealized. The text-book methods followed systematic aims, but as we have broken with the text-books and come in direct contact with the objects in nature, other aims than those of classification have become prominent. In elementary schools, especially, it is not well to emphasize classifications, but to rest the work more upon particular phases of object study and experiment. The studies for children should be individual and biographical. A life history of butterfly or squirrel or fish, with a sufficient consecutive observation into details and gathering of facts so as to

give a deeper insight into habits and mode of life, is necessary. Until we can furnish teachers and children with the opportunity of making such biographical studies in nature, the science work in our common schools must be greatly hampered. The strong tendency of text-books in natural science to be systematic (that is, to give the outlines of a system) almost completely destroys their value for the common schools. And yet all true nature study leads up to the system and order of the universe.

As children gather up the rich materials from the biographies of trees and insects, of fish or bird, they will gradually gain comprehensive views of the chief classes and underlying principles of order. The whole movement in science teaching is toward an adequate grasp of classes and laws. The great mistake is made in trying to begin where we ought to end. Classifications are the abstract forms of science and sum up the results of study, while the characteristic value of early science lessons is their concreteness. Children are easily and naturally attentive to the concrete phases of object study, while they turn away in dislike from the barren study of classes. If we can answer the question how to approach the general truths of science, we shall probably have the solution to the most troublesome problem in this study, and at the same time settle some of the most vexed questions in methods of teaching.

We are not content, therefore, with any of the four

aims of science study thus far suggested. Neither singly nor combined have they sufficient value to stand as the central, controlling aim of the great procession of nature lessons. How, then, shall we find a standpoint from which to survey this broad field of studies and discover the leading aim for its conquest?

We may get a suggestion of the proper attitude for attacking this problem from the child himself. He is the one, after all, who is most concerned with the outcome of our theories. What use has he for this large world of varied realities, both now and in the future? If you ask him the question outright, he will remain as speechless as the sphinx; but if brought face to face with nature's teaching, he may respond heartily in scores of ways. As parents and teachers it is our business to take a sort of composite photograph of a child's present impulses and future needs, and then, by combining our knowledge of children with the garnered wisdom of the world in matters of education, we may possibly discover a method of teaching which will satisfy a child's present growing needs for food and nourishment, and at the same time fit him for his future life in the midst of nature and society. If the old saying is true, that the child is father to the man, that is, foreshadowing what the man will be, he has within him those better instincts and tendencies which, if properly developed, will make him the father of the right sort of man; that is, the instincts which will prompt him to respond vigorously

to those methods of science study which give him the best preparation for life.

We may state the broad aim of science studies as a responsive *insight into nature* with a view to a growing adjustment to the physical and social environment. It is an interested understanding of the materials and activities of the world's great workshop, an appreciation of the variety, beauty, harmony, and law of nature's handiwork. If a child is to reach maturity with a proper insight into physical laws, forces, products, utilities, and inventive appliances, he must begin early to train his eye and his understanding to look into these wonders. Yet this is not a dull business to a child. It is the very thing he is most of all inclined to do if kept in a natural attitude and prudently guided in his employments. It falls in with his present impulses toward physical activity and mental expansion. The native interests which call forth his energetic effort, both physical and mental, are powerfully directed toward the many curious and useful attractions in nature. Nature study should lead to something beyond useful knowledge, sense training, observation, discipline, and the crude mastery of scientific order and system. With these and through them it should appeal to his instinctive interests because of its recognized value to him, because it reveals the physical world to him and to his needs. It thus enters as a constituent element into his own personal culture and growth; it becomes

a part of his life and character. If we devote our whole energy to any of the secondary or subordinate aims of science study, we shall make the work mechanical and superficial and not attain even such lower aims. If we follow the higher aim, to give to each child a personal insight, a sympathetic appreciation of the realm of nature, so far as it can be grasped by his mind, if we seek to enshrine all this knowledge in his tastes, interests, and feelings, we shall find this phase of culture an essential agency in social equipment and in personal character development. It appeals directly to his mental appetites, to his æsthetic tastes, religious instincts, and human wants. It supplies him with the materials and tools for the exercise of his present urgent activities, and its utilities are found to be so interwoven with the comforts and progress of men that nature is seen to lay down the conditions of life. Every child, therefore, should go into nature studies up to the full measure of his powers, and come out enriched in knowledge, in discipline, in sympathetic insight, and in practical power.

CHAPTER III

PLANNING THE COURSE OF STUDY AND MEANS OF SIMPLIFYING IT

To state such an aim as this for nature study is easy, but to show a feasible plan for the accomplishment of the desired result is not easy. The course of study for the eight grades must reveal a rational, well-matured plan reaching this aim. Such a course of study we have attempted to lay out, and the success or failure of this book must depend primarily upon the course offered.

The stumbling-block that often upsets all calculations at the very outset is the complexity of the material included in nature study. The endless multitude and diversity of objects and forces, the large number of wide-branching, independent sciences, as geology, botany, chemistry, etc., are appalling. In any limited department of science like zoölogy, it is not easy to establish the true order of development of the subject, whether, for example, to begin with the lower, simpler forms of animal life or with more complex and highly organized groups. But in nature study considered as a whole, the question

comes how to select and arrange materials drawn from a dozen widely different sciences.

The problem of selecting is still further complicated by the necessity for choosing the science topics with proper regard to the closely related subjects in geography, history, manual training, and other studies. Nor can we confine our studies to pure science. The intrusive and masterful way in which natural science has been coming into our houses, factories, and industries of all sorts, compels us to pay considerable attention to the applications of science to life. So important indeed is this practical phase of science studies, that we will devote later an entire chapter to its consideration.

We seek some plain road by which we can travel through nature's domain, without wandering up and down all the highways and byways of the different sciences.

We believe that the problem of elementary science can be stripped of its complexity and adapted to the simple needs of children. The child's own method of getting acquainted with his little environment gives the key to the solution. The home neighborhood and surroundings of a child furnish us the field of operations, and they are small compared with the vast range of the sciences. In these very limited surroundings there are a few points where his interest and activity are strongly concentrated. We have thus reduced our problem to very small

proportions, and within the narrow limits of the home neighborhood we shall find still other important means of simplification.

From this starting-point we may briefly survey the means of working out a simple course in elementary science.

We have just observed that children's interest and attention are not distributed evenly over all fields of the home environment. There are a few natural centres, such as the house, the school, the local community life and certain attractive neighborhood resorts around which the interests and influences of child life are strongly grouped. The whole body of experiences which is naturally gathered and organized into one of these centres has a strong educative effect. The home, the woods, the river, the park, and a few points of town and country life furnish the familiar centres, and they are most vitalized by ever recurrent activities and interests. Any science lessons which spring from these centres are reënforced by the whole previously developed machinery of habit and experience.

A Few Centres

1. *The home*, in the narrow sense, is the most important of these natural gathering points or organizing centres. Other studies also, such as geography, literature, and history, are best rooted in the home

and its surroundings. But the home or family circle as a starting-point and return goal for elementary science deserves a still greater emphasis.

The home with its garden — plants and weeds, fruit trees, lawn, bushes, shade trees, flowers, birds, and insects; the chickens, horses, cows, and pet animals, with the care needed by them, furnish many of the best simple lessons. The yard should have such shade and fruit trees and the garden such vegetables and flowering plants as will best serve the needs and tastes of the family. The foods prepared in the kitchen involve more science lessons than most people ever learn. The kitchen, the laundry, and the bath room are good places to learn the uses of science. The sleeping rooms and living rooms require the constant beneficence of sunlight and ventilation. The cellar should be an example of cleanliness, by such use of drainage, fresh air, whitewash, and disinfectants as science demands. It is well to understand the benefits and dangers of equipping a house with gas, electric lights, plumbing, a heating and ventilating plant, and a water supply. The sickness and health, the games and activities, food, and dress of children are science lessons for the parents and indirectly for the children. The clothing and bedding, carpets, and upholstering involve questions of cleanliness and health. The fire on the hearth, the moth in the carpet or clothing, the mould on the fruit or bread, the cleansing of

a sink, the ventilation of a room, the care of a bruise, wound, or cold, are science lessons of primary and general importance. The very construction of the house is based upon the best that men have learned about the nature and quality of iron, brick, lime, sand, paint, glass, woods, marble, and other materials. The plans and processes of building require the expert scientific skill of the architect, plumber, painter, decorator, and other craftsmen.

It is easy to see that scores of good science lessons spring out of the comforts and necessities of the home where all these experiences centre. A well-equipped home, in the modern sense, is a centre in which many valuable lessons from the various sciences are focussed. If these topics are found in other respects suitable to the children, their close identification with home interests and needs gives them unusual value and meaning as starting-points in science study.

2. *The local town*, as a centre of community interests, is likewise a focal point throughout childhood. Both town and country children are well known to have a keen interest in the sights and activities of the town. Among the problems of community life are many which have a strictly scientific character, which are appropriate at least to grammar grades, — a system of waterworks for securing pure water, a drainage plan, clean streets, public parks, buildings, and conveniences, the plants of electric, telephone, and other companies, markets

and healthful food supplies free from adulteration, public health and sanitation, infectious diseases and hospitals, temperance and alcoholism, the fire department, and safe construction of large buildings, theatres, etc. Many of these topics are of both public and private concern, as waterworks, drainage system, and electric lights. The curiosity which children feel about town affairs should be led over into these vitally important topics.

3. *The school itself* is becoming a much more important centre of practical science. Its playground and gymnasium for physical training, its school garden and tree planting, its well-planned arrangements for heating, ventilation, lighting, and seating of schoolrooms, and its general sanitary condition, its thoughtful regard for physical defects of eye, ear, etc., are becoming models of the scientific mode of bringing up children. These things, apart from any regular science lessons, should produce an atmosphere favorable to science, in which scientific ideas are respected and applied. The other school studies, also, especially geography and history, by constant interesting reference to scientific topics, contribute powerfully to a respectful attitude toward science. In fact, the school should become more and more a scientific institution, not so much because science is taught as a branch of the curriculum, as because scientific ideas are there made to prevail.

4. In *wild nature* itself, away from town or school,

there are a few natural large units, such as the forest, the pond or river, the roadside (the seaside or the mountain slope in some sections of the country), which are likewise familiar to the children and with growing years become more and more attractive centres of interest. The sports, excursions, picnics, and later the hunting trips, lead the children and youth yearly and with the changes of seasons to these familiar and attractive places. The school has naturally taken advantage of these refreshing lines of experience, early established and long continued, and is planting its lessons where they will find the best soil and nourishment.

Curiously enough, these most frequented resorts of children are likewise what scientists now call life groups, or life societies in nature; and there is now a strong tendency in higher schools to centre scientific studies upon a few of these life groups, rather than upon single specimens of plant, animal, or physical phenomenon. The reason for this is, of course, the close interdependence of the animal and vegetable forms and the physical forces which make up one of these groups. Both in this country and in Europe life societies are now assuming an important rôle in nature study.

A few of these life groups, as we have just seen, by a natural process of selection, are the chosen centres of children's interest and activity. These life groups, therefore, seem to be natural pedagogical,

as well as scientific, centres and units. This falls in, also, with the idea that the units that attract children are large and complex. For example, the plant and animal life gathered at a pond and changing with the rolling seasons is known to form a natural loadstone to children's minds and bodies. The same may be said of the woods, the rocky hillside, or the lake shore.

5. A few of the *primary human occupations* have also become natural rendezvous in elementary science. The farm, with the problems and interests of agriculture, is one of these. The quality of soils, the food plants and their cultivation, the weeds, insects and other animals damaging to the crops, the raising, care, and feeding of farm stock, the weather conditions, the rotation of crops, the machines and inventions needed for economic farming, now centre upon the farmer's work many important results of scientific knowledge.

Agriculture has always been regarded among civilized people as the most common and universal of human occupations, from which all persons of other trades or of no trades draw subsistence. If, now, we associate gardening, the orchard, fruit-raising, and forestry with farming, as closely allied industries of the soil, we have a group of topics of direct interest to all children. So important is gardening and fruit-growing, that school gardening and tree planting and culture are already demanding attention in many

schools as a necessary part of the schoolhouse surroundings and of the course of study. At a glance it is plain that raising vegetables and fruit trees in a school garden, combined with questions of soil and its fertilization, of noxious insects and grubs, of conditions of heat and moisture, means the direct introduction of a whole series of valuable science topics into school studies. These topics may be already in the school course, but linking them with the actual work of children in the school garden and in their home gardens may give them a meaning and force they have not hitherto had. Farming, gardening, fruit-raising, and forestry, reënforced by the discoveries and experience of scientific experts, bring out distinctly some of the best lessons in botany, zoölogy, and geology, while physics, chemistry, and meteorology are perhaps equally in evidence.

There are a few other primary occupations, as coal and other mining, textile manufacture, fishing, and modes of transportation, which are important centres for the application of scientific knowledge.

These few topics (home, school, town, the life societies, and the primary occupations) are the pronounced centres of interest in the child's environment where the soil is prolific in valuable science topics. They are the chief centres of the child's own life, and they remain so through life, so that the focussing of many lessons in each of these centres has a permanent basis.

A still further and complete reduction of this home environment of the child to its simplest elements is secured by the use of types as lesser centres of study. These types include life histories of plant and animal, objects and phenomena in physical science, and processes and inventions in applied science. We have discussed elsewhere the meaning and value of these types. While the types are of less striking importance in primary grades, their value becomes greater and greater as we advance in the course, and they lead up unmistakably to such classifications and laws in nature as children are able to grasp. The purpose of pure science is to simplify and organize the apparent diversity of things in nature and the type studies are the safe pedagogical route to this result.

Let us now make a summary of the movement by which we get a simplified science course.

1. A strong emphasis of the neighborhood environment of children.

2. A concentration of effort upon a few natural centres in this little world of the child (home, town, school, life societies, and primary occupations).

3. The selection of the best available types out of these neighborhood groups as the real units of class-room study (life histories, objects, processes, inventions).

If this plan of simplifying the science course is based upon a proper estimate of the powers of

children and of the nature of the science materials, it will enable us to escape from the yoke of bondage which the sciences as such, in their classified form, would impose upon us.

The scientist who is making a formal text-book for the schools is controlled by a point of view and an authority which stands at a wholly different and far-removed centre of operations from the above. The little environment in which the child lives is such a tiny and particularized fragment of the whole field, that the scientist who surveys the whole from the standpoint of general principles has not his eye focussed to see the child at all, nor his little world.

Another curious fact is that when the scientist gets down to what he terms simple principles or primary elements of his science, he is still as far away from a child as if he had remained in the field of broad, general concepts. In fact he is still in this field without knowing it. A child does not want the alphabet (that is, the simple principles) of science any more than he wants the names of the letters of the alphabet when learning to read. What a child wants, of course, is to better interpret those things around him with which he already is most familiar. He possesses the alphabet of science in his knowledge of things; what he needs is to observe more closely and to put things together for better interpretation.

The topic which a child encounters in his home or in some other centre of experience lies embedded in its surroundings, — if you please, in the very thicket and jungle of things; but it is a familiar jungle, and one in which and from which the child is constructing his own habitation. It was by hewing down the trees of the forest that the pioneer found a place for his cottage, and let in the sunshine to reveal the richness of the soil for producing corn and pumpkins. Each child likewise is hewing about him to make a clearing large enough for his home and needs. We have seen that science topics spring up in the home as thick as plants and weeds in the garden. To grapple with these things in the home environment is to meet and master them on their own ground.

There is another great advantage in taking science where we find it in these centres of life's activity, and not in some isolated scientific form in laboratories or text-books. The child who draws his knowledge of science directly from life, under usual conditions, will not have much difficulty in finding it again in life and applying it to life. It is not difficult to so isolate the study of physics and chemistry, or even botany and zoölogy, from the usual conditions of life that the student in after years will have more difficulty in rediscovering his knowledge than he had in first acquiring it. But the child who learns from the start to trace facts to their native lair will recognize them again under similar surroundings.

In the usual study of the natural sciences, each science centres its materials around its leading principles, but from the home as a centre radiate problems into all of the sciences: proper ventilation is based on physics and physiology; proper cooking refers back to chemistry, botany, zoölogy, and to several other sciences; house sanitation draws from most of the sciences; the heating and lighting of a house carry us into several fields of applied science; and so with other household economies. Now it must seem clear that the home is pedagogically a much better centre of thought for children than any one of the sciences, and far better than all of them in their several unities. The natural large units of thought must be those places where the greatest body of the child's experience centres. Again, these centres of which we have been speaking persist from the beginning throughout the whole of life. They will never need to be torn up and distributed to other centres; for the adult, like the child, will still find in himself, in the home, and in the common social interest of the community, the ever strengthening centres of his thought and life. In later years he may devote himself to a study and ordering of one or more of the separate sciences; but their chief merit, after all, will be the service they are able to render to these aforenamed original centres of human interest and action.

In a similar way, but on a smaller scale, each man's trade or business is an organizing nucleus. Each

human occupation, like farming or coal mining, is a natural practical centre from which radiate a goodly number of science problems. The farmer, whether he is dealing with machines (physics) or soils (geology) or plants and animals (botany and zoölogy) or with weather conditions (meteorology), needs for immediate purposes the help and knowledge which the scientist has garnered. Why is it not good for the child to take the farmer's standpoint, and from this position look for advice from the sciences? It seems to me that there are great advantages in this starting-point and in this attitude toward science. It is the genuine situation as practical life presents it. It gives the child the right motive for investigation. It takes him where we find him, for he has already been studying about the farmer in his geography lessons. In his own and in the school garden he has met with similar problems of the soil and of plant life.

Again, from the standpoint of very important social and industrial aims in education, including manual training, there is a very strong and active impulse among educators to concentrate instruction upon a few typical occupations. What carpentry and woodwork are and always will be for indoor shop work, the garden and farm will be for the outdoor industrial life. It seems highly desirable that the whole group of employments connected with gardening, fruit culture, and to some extent with farming, should be directly associated as much as possible

with the work of the common schools. The provision of a garden for every school is bound to be a live question for every teacher.

If we should take each of the natural sciences as a controlling centre of study, we should have a complicated and difficult, if not impossible, course of study for elementary schools. If, on the other hand, we allow ourselves to range unchecked through any and all fields of science, picking up whatever comes, we shall have no course of study at all, at least none which can serve as a basis for systematic planning and careful preparation of teachers, none which can be followed consecutively by one school and by different schools.

CHAPTER IV

THE BASIS FOR SELECTING AND ARRANGING TOPICS FOR THE COURSE OF STUDY

We may now inquire into the grounds upon which a selection and arrangement of topics for a course of study in the eight grades can be based. A number of considerations should be kept clearly in mind in making this selection. As nearly as we can define them they are as follows: —

1. The commonest objects of the home should have the first place. The common weeds, as the burdock and thistle, are better than exotics. The things we trample under foot are quite as wonderful as anything in India or Japan. These commonplace things should be made the real eye-openers for children. When properly approached, they give the true basis for close observation and examination. They should come first, also, because they are the proper preparation for the study of more distant objects. The home also furnishes a sufficient variety of good types for the various fields of nature study. Elementary science, more perhaps than any other study, is home-abiding and begets respect and admiration for common things.

2. The study of plant and animal life seems peculiarly appropriate to children in the earlier years of school. They like especially the activities of animals, the observation of their movements among the trees, in the air, or in water. Of all things in nature, animal life comes closer to the children because they find so many likenesses to their own activities. Plants and flowers also attract them, and they love the changes and processes of growth, the seeds, flowers, roots, fruits, and uses of natural products. There is a sort of personal interest in the study of animal or plant that is lacking in other forms of nature study. The seedling plant grows, feeds, and develops as does the child. It has its dangers and enemies, its childhood, maturity, and old age, its winter and summer. For a child to trace the butterfly from the egg through its processes of change and final perfection in the insect state is an interesting biography.

The study of plants and animals will hold an important place throughout the course, but other studies become increasingly important in intermediate and grammar grades, so that relatively less time will be given to biology.

3. Topics from the physical sciences (physics, chemistry, meteorology, geology, and astronomy) have an increased importance as we advance in the grades. Some of the simpler phases can be taught in primary grades, but most of these topics are of

such difficulty as to belong later in the course. The various applications of science to life, as machines, inventions, and sanitary arrangements, begin in fourth and fifth grades, and become increasingly important as we advance. Lessons in physiology, cooking, and temperance are chiefly suited to the intermediate and grammar school. In all these cases a careful grading of topics according to their difficulty and suitableness is necessary.

4. In laying out a course of study on broad and simple lines, we should observe that certain large topics are continuous from year to year through the grades, and they need to be arranged on some simple plan of development from easy to more difficult. For example, the lessons in physiology can be distributed through the grades from primary to grammar school somewhat as follows: foods and the teeth, the skin and its uses to the body, the eyes and ears and their proper care, the digestive system, the heart and circulation, respiration, the brain and nervous system. The topics on temperance and cooking and useful inventions should be arranged in a similar advancing series. The topics derived from each of the five home centres (home, town, school, life societies, and primary occupations) should form several series, developing through the grades. For example, the pond as a life group may furnish a succession of topics through intermediate and grammar grades as follows: pond life in the fall

(a general observation of plants and animals, willow, sedges, rushes, etc.). Pond life in the fall (special study of turtle, muskrat, and mussels), aquarium. The pond in the spring (special study of frog). Water birds, as duck, grebe, snipe, rail, etc. Pond in the fall (fishes and use of aquarium). Insect life in the pond (giant water-bugs, dragon-flies, fairy shrimp, mosquito, diving-beetle, metamorphosis of insects, etc.). Construction and management of aquarium. The pond as a life society. The pond in winter. Study of minute animal forms, as Daphnia, Cyclops. Thus the pond studied at different seasons and with a special emphasis on new topics in successive years gradually grows in interest and reveals the conditions and laws which prevail in a life group.

The advantages of this serial arrangement in each large subject are many. It gives specific emphasis to new and interesting topics each year. It furnishes excellent opportunity for instructive review without the dulness of mere repetition from year to year. It prepares the children gradually for more difficult problems in succeeding grades.

5. The season of the year must determine to a large extent the best time for the study of plants and animals and many other topics. The budding and blossoming of the trees must be noted in the early spring. The bees can be studied in spring or fall; the spring plants may be dug up in springtime; the seeds and pods are best noticed in autumn; the ever-

greens may be taken in winter and spring. Of course, any given tree or plant needs to be traced through the season; the robin should be seen on his spring return, in the nesting season, and when he returns to the South in autumn.

The winter season is the favorable time for the study of many topics from the physical sciences and from practical applications, inventions, etc.; also from temperance, cooking, and other topics which do not require outdoor labors and excursions. It should be remembered that about one-half of the school year in most parts of the United States belongs to the winter months, where the chief emphasis must be placed upon indoor science studies.

The relation of the spring studies to the fall studies brings up quite an interesting and important problem. A number of topics which are begun in the spring need to be continued through the summer and fall. This is true in plant, insect, and bird life, and in the study of pond, forest, and field. But the long summer vacation interrupts this plan, and in the fall a child enters a new grade with a new teacher (at least in many cases). The life history of many plants and insects is bounded by the single season, and should be continuous from spring to fall. The succession of changes brought by the circle of the seasons in many cases furnishes the best units of study, as in the corn plant, the wild duck, and the forest trees.

By an examination of our course of study it will be seen that many important topics are carried over from the spring into the fall. In such cases we assume that teachers are able to look back across the summer vacation and to know effectively what was done by the class in the previous spring under another teacher. This is required in other studies. Why not in science?

In selecting science topics according to the seasons, there is much danger of studying the same topics from year to year till their repetition becomes tiresome. This is often true where no course is arranged for the grades, and teachers from year to year select and work over the same familiar subjects. In a properly arranged course new objects will be made the centre of study, and the old ones will serve for interesting comparison and review. A wisely arranged course extending through the grades may constantly enrich the old topics by new studies taken from the same seasons and environment.

6. Other studies, especially history, geography, and literature, often suggest the best place for the treatment of science topics. The literature of primary grades freshens up many topics from plant and animal life. Hiawatha, Robinson Crusoe, and the myths are very suggestive of outdoor scenes and useful inventions. The pioneer history stories abound in the scenery and objects of the natural world. The geography of the same years deals pre-

eminently with natural forms and products, and with those scientific inventions and processes by which man has learned how to use them. In history we find that many scientific machines and discoveries have had an important influence on progress. We have explained elsewhere the fact that geography and history prepare the ground for science topics, and that the science lessons in many cases are merely a continuation, from a scientific point of view, of topics which were begun but could not be completed by those studies.

These considerations have influenced us in choosing and locating a number of topics, though it may not appear without examining the courses in the other studies. The course of study in the Special Method in Manual Training will show that many of its topics are continuations of science topics, so that the science course both gives and receives aid in its relations to other studies.

7. The careful selection of suitable types will much reduce the number of topics to be treated in all the grades. A clear insight into the controlling forces in nature and in human affairs is also more easily gained through type studies.

It is well to make a full and careful study of one of the rodents, as the fox-squirrel, with the descriptive detail of his nest, habits in summer and winter, his food and rearing of the young, his enemies and devices for escaping them, his noises and movements

in climbing and running, his fur and its uses, the make of his teeth and claws as suited to their uses, and his kinship with other squirrels. Such a biography of individual and family life among squirrels gives not only a graphic picture of this little animal, but allows a variety of observation and comparison with other animals, similar or contrasted, that may be incidental yet valuable. In the same way the cow among ruminants becomes a type of that order, the milkweed butterfly among butterflies, the maple or oak among trees, the dandelion or thistle or sunflower among composite flowers. The type form, when fully described in its continuous life history, is not only a very interesting and instructive object to children, because of the abundance of attractive detail, but it is a key to the understanding of a multitude of similar or related plants or animals. The study of the cat, for example, as to retractile claws, eyes, and muscular and bony structure, gives a clear view of a whole group of animals. A brief comparison of the domestic cat with the tiger, wildcat, etc., is all that is needed to make the knowledge fairly complete. Without the guidance of these larger units or type forms, the topics chosen by teachers are often very partial or miscellaneous. For example, the study and comparison of leaves on trees, the comparison of twigs, and the arrangement of buds and twigs, or leaves, on the stem. Such topics come up incidentally and naturally in the handling of a type.

The objection of some writers to this use of types seems to be based upon the mistaken idea that the type is equivalent to a general notion or abstraction, and that children are pushed prematurely into abstract thinking. There is some ground for this criticism, especially in the work of the earlier years. But the superabundance of concrete material, the demand for comparisons and for the tracing out of causal relations, are quite sufficient to overcome this objection. The conversion of types into mere abstractions is a perversion of the whole plan.

The selection of a few important type studies, each of which is to be worked out in full detail, has the following advantages: —

(*a*) Each type is an important centre of thought around which to associate a large body of related material.

(*b*) Each type is the representative of a large class of more or less similar objects (basis of broad classification).

(*c*) Great abundance of concrete material is gathered about each type object, contributing to interest and clear perception.

(*d*) A continuous biographical study of life history or development has strong, consecutive force.

(*e*) The deeper causal and vital relations that bind plant or animal to its environment can only be traced out by this detailed study of a single important object.

(*f*) A single important topic is kept before the

children long enough not only to gather up a varied collection of experimental knowledge about it, but to organize it, and to bring it into relation to other topics in all the studies.

(*g*) The type studies pave the way to a recognition of *general laws* in natural phenomena which give the most comprehensive views. This process of working up to an understanding of the general laws of nature is so important that we will consider it separately.

CHAPTER V

THE GRADUAL APPROACHES TO SCIENCE

One of the ever present problems in the mind of the thoughtful teacher in elementary science is that of the amount of science proper resulting from such instruction. How much pure science in the form of classifications and laws should pupils of the elementary school acquire? Perhaps it may be truly said that theorists and book-makers require too much science, and teachers and pupils get too little.

It is well to avoid the two extremes, that of burdening the children prematurely with classified knowledge and that of giving loose, helter-skelter information about all sorts of science topics.

As a rule, teachers are overhasty in urging children toward generalizations; they wish them to leap from one or two facts or examples to important conclusions or classifications. The teacher should keep these things in the background of her own mind to serve as general aims which she has plenty of time to work out. At the same time instruction must keep these landmarks of the scientific movement clearly in view. From this consideration the following passage translated from Junge as quoted by Rein may be suggestive to teachers.

Children are to acquire gradually an insight into the unity that prevails in nature. At first the endless variety of objects and activities in nature gives a child no notion of the underlying harmony and connection of the varied parts; but as the insight into wide-reaching laws is revealed to him he finds strong links of union, binding all the parts into one.

This unity shows itself in the life of any plant or animal, in the laws which govern its internal organization and external adaptation of organs to environment.

Junge, as quoted by Rein, presents this unity in nature based upon laws as follows :—

"Life is characterized first of all by the fact of *movement* either of the inner parts of a body (its constituents) or of the external parts or organs.

"Through this movement is brought about (1) the growth and development of an individual from a lower to a higher stage of completeness; (2) the preservation of the thing itself. The indwelling effort of all the parts or members toward the preservation and perfection of the whole is the life principle (law of preservation, accommodation — of organic harmony, of development). Let the impulse to harmony of inner or external movements cease, there enters a condition of decay and death.

"Life in nature is a unit not simply as far as each organism constitutes a unity, but also so far as an agreement shows itself in the inner causes of life

activities in different individuals, that is, so far as laws manifest themselves. The laws prevailing in individuals have at least a strong resemblance to those which rule in a whole group of individuals, a life society (even the earth considered as such), though the laws are not just the same.

"Should we inquire upon what road a knowledge of the facts and changes in nature, both in single things and in more complex wholes, may be reached, a brief consideration will give us a ready answer. The simpler, *i.e.*, the less intensive and extensive life displays itself, the more easily can the laws of its manifestations be recognized. They are more easily perceived in the changes of inorganic than in those of organic nature. The life of a lower organism is more easily understood than that of a higher; the life of a single organism easier than that of a life society; and, finally, the life of a group or life society, accessible to observation, more easily than one of the whole earth. The following serial order, therefore, results: 1. observation of life in the single thing and successive recognition of the different fundamental laws; 2. recognition of the discovered laws in small life groups accessible to the child's view; 3. application of the laws to unfamiliar objects and life societies; 4. application and rediscovery in the entire life of the earth. It is not necessary to satisfy the above-mentioned requirements in a strict schematic way. Schematism would

do violence to organic development and comprehension. It is rather advisable at every stage of progress to aim at a well-rounded whole, and in view of the final aim to make use, little by little, of the results springing from the other natural sciences as the progress of instruction renders them possible."

In biology, which furnishes a large share of the topics for science lessons, there are two kinds of units of thought, single animals or plants and life groups. The single animal or plant, as a type, we have already discussed. The biographical story, or life history, in full, of such a plant or animal, especially when brought into comparison with similar biographies of other plants or animals, reveals many of the fundamental laws of organic life in nature.

The *life society* or group is a much more complex object of study. It is not a systematic group, but a natural group of closely related and mutually dependent objects in nature. A natural forest well illustrates such a group, — the various forest trees, the wild flowers and grasses peculiar to woodsy places, the birds and squirrels and insects that naturally find their homes and food among the trees. Even the soil, moisture, and sunlight, among inorganic things, contribute to the conditions for a mutually dependent and helpful group of living organisms. The birds depend upon the trees, the trees depend on insects for the cross-fertilization of flowers; the bloodroot and other wild flowers flourish in the shade of trees.

The study of the different members of this family group, and the study of the whole varied family in its relations, will bring out still other fundamental laws in nature.

Rein says, "As the basis of our studies, we are called upon always to select a natural whole; and first of all, such a whole is found in every single living object, for each is an organism, *i.e.*, a thing whose parts stand in relation to one another and to the whole." Nature study, therefore, should deal not with fragments, but with wholes; not with leaves or buds as isolated topics, but with trees or plants as wholes, of which the leaves or buds are parts. The unit of thought should always be in mind and stand as the basis of study. "A single living organism, however, is only a part of the great world machine. In many of its relations it is dependent upon other objects, as a strip of earth, etc., which influence it and in turn are influenced by it. Thus we find different objects together. A number of objects bound together by common or similar needs, or by mutual aid rendered, form a *life society* in which each one fills out its place and part in the whole. These life societies are considered as composed of organically connected single things. When several such life societies, as, for example, forest, field, swamp, meadow, etc., whose unity the children can survey, are observed and their importance for the home brought out clearly, for which all taken together

constitute a unity, — by such observations the way is prepared for an understanding of the entire life of the earth. Such wholes, whether single objects or life groups, we analyze into their parts, and inquire what parts are these, what purpose have they, and why so made and not differently? With a plant before us we notice the parts. As to the root, we observe not only its fibres, but its work, and why so constructed; why different in sand, or clay, or in rich soil. The leaf is noted as to form, also its function and the reason for its being flattened out; why in water-plants it is modified by the depth of the water; why in land plants it is sometimes hairy, sometimes hairless. So, also, in the study of animals. Organ and function should always be brought into the closest relation. So we come to understand why a foot is modified to adapt it to a changed purpose, as a webbed foot, a wing, or a hand for grasping; why the skeleton of birds, for example, is different from that of mammals."

By the constant emphasis of the correlation between organ and function, the child's mind is kept awake to the fact that he has to do with a living thing, for the eye must pass from the construction of the organ to its use in life, and *vice versa.* In the second place, we satisfy the demand for causality, which is really the impulsive element in the development of the human mind. That this is present in the child is manifest in his many "whys."

The discovery of these laws and causal relations between objects and life groups in nature reveals in a striking way the total inadequacy of a method of science study which isolates the different sciences, as botany or zoölogy, and tries to build up a system and classification of each by itself. In the biography of any animal or plant, and also in the life societies, the vital organic relations between plants, animals, minerals, sunlight, etc., are cross-sections in the sciences, which disregard our efforts at isolation and artificial system making. It is in these interrelations of the different sciences that we find the deeper and more instructive causes operating in nature. Classifications in botany or zoölogy are important, but the study of causes acting between different sciences is often more significant, instructive, and stimulating.

"So long as no law has been worked out, the teacher must be the guide in making observations. The laws, or rather the final aim of the natural science instruction, must be ever present to his thought, whether he be selecting the material of instruction or employed in its treatment. When a law has been once recognized, then in many cases it may assume the leadership; it gives direction to present undertakings as well as to future observations and experiments. Pupils now examine living creatures according to the measure of one or more laws; they begin to investigate the question whether, in a given creature, manner of life, habitat, and

structure of organs correspond, or whether an organism develops from a simpler form up to a stage of completeness," etc. (Rein.)

The last sentence suggests the two simple fundamental laws by which most of the phenomena of organic life (plant and animal) may be interpreted, and a deep insight gained into life processes.

1. Manner of life, habitat, and structure of organs correspond. Every animal or plant is peculiarly adapted by its organs and mode of life to its environment. To discover and trace out this law in the varied and widely divergent forms of life, is one of the most instructive and permanently stimulating thoughts in nature study. Law of physiological purpose.

2. Every organism develops from the simple up to the stage of completeness. Here again, to trace the life history through its successive stages of growth up to maturity, reproduction, and decay, reveals amidst endless variations a sameness and constancy of life processes which make nature's work almost wonderful in its simplicity. Law of development.

Still other important laws which may develop out of thoughtful nature studies are taken from Junge, as follows: —

3. Manner of life and structure of organs adapt themselves, within certain limits, to a changed habitat or set of relations. Beyond these limits follows the death or crippling of the organism. Law of adaptation or accommodation.

4. The more the whole work is distributed to different organs the more perfect is its execution. Or, the more numerous the organs for different services the more perfectly can each organ perform its special service. Law of division of labor.

We have dwelt somewhat at length upon these biological laws because they serve so well to illustrate the possibility of making such a study of nature in the organic as well as in the inorganic world as will lead on to a simple and practical conception of the unity in nature. Moreover, it is the actual unity which, as based upon persistent and omnipresent relations of cause and effect, reveals nature in her ordinary dress and not in the somewhat artificial form of scientific classifications, isolating the different sciences from one another.

In the physical sciences there is also a body of important laws which are worked out and illustrated from examples. The machines and inventions by which men make use of the forces of nature are good illustrations of the operation of important physical laws.

In the study of life histories, life societies, and in the working out of simple fundamental laws, we may lead on to a grasp of the unity of life processes in nature and to such an interest, insight, and habit of study as to greatly influence character.

Here, however, we must repeat a caution. Teachers and adults are prone to give emphasis to general

laws, far beyond what children need. These laws are valuable regulatives and guides to the teacher; but they come slowly and gradually to the consciousness of children.

The influence that nature study has upon character depends largely upon the hold it gets upon the child's affections. It is not simply a matter of discipline, but also of attachment and interest. The sources of stirring interest for children in nature study are so abundant as to give a strong and steady impulse to work and will effort. Herbart has pointed out clearly that three of the great fountains of interest and inspiration spring from the roots of nature study as the sources of great rivers gush from the foot of mountains.

1. The empirical interest so universal among children deals with the superficial phases of nature's manifestations, — the change, variety, and generally pleasing and attractive face of nature. There is, even among little children, a native powerful impulse to get into the fresh air, the sunshine, and outdoor contact with nature.

2. The speculative interest works down into causal relations, gets beneath the surface of phenomena, and reaches out over broad areas in search of more or less general laws. The causal idea is an all-powerful impulse alike for children and mature scientists.

3. The æsthetic phases of nature's handiwork, the

beauty of form, color, and proportion in the flower, bird, insect, cloud, and mountain, furnish limitless and constant opportunities for æsthetic appreciation and culture. Many think this the choicest part of nature study.

CHAPTER VI

THE APPLICATIONS OF SCIENCE TO LIFE

We are accustomed to hear much said of the remarkable achievements of science in connection with steam-engines, electricity, telescopes, hydraulic machines, and a few other great inventions. But we seldom consider to what a wide extent all forms of industry and common modes of life have been changed by recent advances in science.

The applications of science to life have so transformed our surroundings that we live in a very different world from that of fifty years ago. To live properly in this new world is to understand it, to fit into it, and to make the best use of it. Since the changes are due chiefly to scientific inventions and improvements, progress in education calls for a direct and more practical acquaintance with sciences by common people.

Every important invention or machine of applied science calls for a new expenditure of intelligence and foresight on the part of the many people who use it. By bringing sewer connections into a house with water-closets, traps, sinks, and soil pipe, the family is exposed to the most serious dangers unless the system is kept effectively clean and in good working

order. With dirty sinks, leaky traps, and exposed cess-pools the whole system breeds danger and disease. The use of gas in houses, of gasoline stoves and oil lamps, of furnaces and ventilation, requires added intelligence and thoughtfulness.

The tighter and warmer the construction of our houses against winter wind and cold, the greater the need for a complete plan of ventilation. But it is very difficult to get a good system of ventilation into a house, and still more difficult to find some one intelligent enough to use it in connection with a heating plant. Yet these are prime necessities in a house containing modern scientific improvements. In a well-regulated household, with modern appliances, there are dozens of places where a superior intelligence is needed in order to make proper and healthful use of the appliances which science has put into our hands. Everywhere these improvements have been coming rapidly into our homes, and they are destined soon to take full possession of them. But for their proper use the definite intelligence of the people everywhere is necessary.

It is generally conceded that the public school should apply itself to those parts of knowledge which are of general or universal application. The knowledge which is peculiar to special trades and professions, as brick-laying, banking, medicine, dentistry, or boat-building, is of secondary importance in schools; but that knowledge which every human

being needs in order to be healthy and efficient in his life work is what the school should emphasize. A very large number of the applications of science to life have this universal quality. Like the air and sunlight, they are of common benefit to all men. It is true, first, in regard to all those things which belong to the equipment of the home and to the physical health of the individual, and secondly, in regard to all those which are community benefits, as public sanitation, means of communication and travel, and all sorts of town or municipal improvements. These latter are also social benefits which bring all men into closer relations of helpfulness and dependence upon one another. Both the small affairs of the family at home, and the large affairs of the community and of the nation, are very much under the sway of these scientific improvements of our age.

But science has also reached out with a strong hand and taken possession of the great industries. In agriculture, in manufacturing, in mining and transportation, the gigantic steps now taken are quite as remarkable as some of the exploits of the old myths. A locomotive engine with seven-foot wheels is as far removed from the ox cart of two generations ago as Hiawatha's magic slippers from the shoes of the ordinary walker.

> "He had moccasins enchanted,
> Magic moccasins of deerskin;
> When he bound them round his ankles,
> When upon his feet he tied them,
> At each stride a mile he measured."

Most of these great topics history and geography deal with in a large way; but the science lessons give the keynote to a definite understanding. That is, history or geography carries these topics of industrial and social life a certain distance, then the sciences must go deeper into the explanation of things, into the real causes and forces at work. The geography lesson discusses corn and wheat production; but the special treatment of insects damaging the corn and wheat, or of topics relating to the qualities of soil and fertilizers, must be turned over to practical science. Geography gives a description of a coal mine; but the science lesson explains the origin of coal, the machines used in hoisting, and the construction of the safety lamp. History lessons often mention the importance of the mariner's compass to Columbus; but a science lesson explains the compass.

It is worth noting, also, that these bearings of science on life are not confined to any one science or group of sciences; but from all the realms of scientific knowledge come these fruitful applications. Geology is helpful to the miners in gold, silver, coal, and other minerals and metals, and even to the farmer. Building stone, fertilizers, clays, cements, etc., refer back to geology. The importance of heat, light, sound, and electricity as developed in physics and used in great industries needs but a mention. Chemistry is at the basis of mining and manufacturing operations. Botany and zoölogy, as shown in our agricultural stations,

are opening the eyes of farmers, gardeners, and fruit growers to the nature, difficulties, and opportunities of their business. Meteorology and the weather reports serve the common good. It is superfluous to specify other varied applications of science; but it is at least worth while noting that this sort of practical science study has no narrow range, that it reaches into all the important and essential human affairs, both public and private, and that it also brings under interesting investigation many important phases of pure science.

In order to secure the enforcement of many sanitary and social improvements of a scientific character, it is essential that the people generally should have intelligent ideas about such matters. It is now well known among a few people that pure milk can be had only by definite arrangements and precautions in the dairy and in the shipment of milk. It is also well known that for the lack of these precautions great quantities of contaminated milk are sold, and that the death-rate among children and older people is much increased by the common use of such bad milk. Science has established the facts, and abundant practical experiment in dairies has proved beyond question the proper means of securing good milk; it remains only for popular intelligence on this subject to be so disseminated through the schools that an overwhelming popular sentiment will make it impossible among dairymen and milk venders to resist this improvement. Exactly the same thing is true in re-

gard to the public supply of pure water by cities, in regard to the disposal of sewage, the provisions for isolating people sick with consumption and other infectious diseases, in regard to the pure food laws, and other sanitary and social regulations based upon scientific knowledge. Science in various directions has demonstrated the laws of life; but popular intelligence gained through the schools is the reserve power which will steadily force people to practical consequences. It is well known that dairymen and milk dealers, because of ignorance, unwillingness to incur expense, or wilfulness, are slow to make the desired improvements; city officials are often culpably careless and negligent of public needs, till some sort of popular outbreak strikes them and forces a reform.

The education of the people in these most essential matters is altogether important in our country where popular sentiment settles so many questions, and where authorities often follow rather than lead the people.

Another important result of a proper teaching of practical science in the public schools is a growing respect for science and for scientific specialists. Our age is sometimes called an age of specialization, and the movement in this direction is very marked in universities, in the medical profession in cities, and in many occupations and industries. But in spite of all this there is among the people generally a com-

mon lack of respect for specialists and for science. This is well illustrated by the quantity of patent medicines sold and swallowed. The success of blatant quacks in many callings is a further illustration. People allow themselves to be imposed upon so much that they lose the power or desire to discriminate between impostors and scientific specialists. This is primarily a matter of education, and of the proper teaching of the applications of science to life. President Eliot of Harvard said a few years ago that the standard of intelligence among the people could be measured by the degree of their respect for real specialists. Gauged by this standard, the intelligence of the American people at the present is not of a high order.

But the teaching of the applications of science so as to increase this sort of intelligence and respect for specialists has been little developed in our schools. It may be said with moderation that in the great majority of schools it has not been taught at all. I think it can be shown without difficulty that in scores of lessons showing the uses of science in the house and in the community the value of expert, scientific knowledge in common affairs is unmistakably demonstrated.

Suppose we ask children the question, How may we find out whether the water in our well, or drawn from the faucet, is healthful and pure or not? There are but two possible ways. Let all the people drink

it and see how many sick people are the result. The other is to get it analyzed by an acknowledged specialist at the state university or elsewhere. What is the best way to boil an egg? Specialists, by careful experiments with eggs in hot water tested by the thermometer, have worked out this result. How may a sick room be disinfected where a patient with a contagious disease has suffered? How does an insurance company find out whether a man has good health and is a good risk or not? These are but random illustrations to suggest where the true source of genuine knowledge is best sought.

Turning to the more direct school question as to the quality of these science lessons and their suitableness to the school, we notice first that they are everyday, prominent topics which force themselves upon the attention. The thermometer, the pump, the windmill, the stove, the steam-engine, the barometer, the clock, the scales, an electric bell, a rifle, a microscope, a camera, a telephone, are a few of the common machines and instruments which intrude themselves upon a child's attention, while questions of pure water and milk, temperance, contagious diseases, cuts and bruises, cleanliness and sanitation in the house, poisons and disinfectants, the kitchen and cooking, the stomach and digestion, bodily organs and hygiene, public sanitation, and many others similar, are obtrusively present in daily life. We need not go far, therefore, to find these practical

science problems. They environ us constantly and press upon us for attention.

The motive to investigate and to understand these common and striking things would seem to be natural and spontaneous. Yet children often show little desire to know them. With these as with most other familiar things, they turn but little closer scrutiny upon them till their interest is properly awakened by thoughtful parents or teachers.

But there is one great advantage in this class of objects. When once the attention of children is drawn to them, and they discover how closely such topics are bound to the common needs of life, the interest in them is greatly strengthened and the purpose to find out about them aroused. In other words, they furnish a strong *motive* for study and one that appeals to the children by its own merit. It would be difficult to find a more vital principle than this of a motive springing up in the child's own mind and aroused by his own perception of the meaning and value of knowledge. It is closely linked with the idea of *self-activity* which is sometimes set up as the comprehensive and dominant principle of all education.

Another advantage of thus first encouraging science in its practical manifestations is that one can always return to it and find it again in this dress and surrounding. This is really its home, its proper habitat, and these are its permanent associations.

The laboratory of the botanist or chemist is a necessary part of the machinery of investigation; but the place where the giant puts his shoulder to the wheel in good earnest is in the practical work of life.

We are inclined to think that children in approaching science are at first more interested in the results than they are in the long series of experiments leading to the results, that they move backward from life into the laboratory, better than they move forward from the laboratory into life. One of the chief reasons, as indicated above, is that the motives for investigation spring better out of the contact with life's needs and necessities, than from the artificial conditions of the laboratory. The scientist, intrenched in his science, is inclined to organize his work around the principles of his science and to regard the world of nature and of practical life as a source from which to draw illustrations. The teacher finds that the child is already domiciled in this outside, practical world, that he has grown up in it and will continue to dwell in it, and when he begins to get an inkling of the problems by which he is surrounded it is well for him to reach back into the workshop of the scientist and see what help he can get in interpreting his life problems.

We believe, therefore, that these practical applications of science to life as a child meets them in his home and surroundings are the entrance way to science. They furnish the points of contact between

man and nature, especially those points of contact which are manifest to all and first attract a child's notice. In a deeper sense, of course, the scientific investigator is in most vital touch with nature, just as the theologian may be in most vital touch with the great truths of religion. But the theologian, with his systematic theology, should be kept as far away from the child as possible. In fact, he is no proper part of a child's environment. Nor is the mere scientist.

From all sorts of problems arising in the contact of life we shall be forced back into the scientific laboratory. How may sugar be gotten from beets? The chemist is the only man who has been able to work out the problem. How may we find out whether the ore taken from a gold mine is profitable? The assayist must answer. How may crude petroleum be brought into serviceable shape and its various products obtained? Only the trained specialist can tell. From how deep a well may water be pumped with a lift-pump? How may we find out whether the lungs and heart have a healthy action? How may we prove and illustrate the circulation of the sap in a plant? These and many other questions can only be answered by the specialist with his instruments or laboratory equipment.

The effort to interpret these machines, instruments, and processes from practical life will demand a strong exertion of intelligence. It will not be mere enter-

tainment and play. Through the intermediate and grammar grades we may count on serious and laborious subjects of study. To interpret even the simpler machines and scientific contrivances requires concentration of thought. A pump, a thermometer, a pair of scales, a siphon, an hydraulic press, a rope and pulley, a violin, to say nothing of a steam-engine, an electric light, or a sewing-machine, require a genuine effort of thought. In fact, it may seem to those who have regarded nature study as entertainment and recreation rather than serious study that the labor we are calling for is out of all proportion to the abilities of children.

Another point which we are also compelled to consider is the fact that most of the problems presented by practical life are complex, involving several elements. Even such a simple thing as a lift-pump or a bicycle pump involves several elements, the forces at work and the mechanical devices. The teacher in the laboratory is apt to think that he can grade a much simpler series of experiments in his laboratory than outside life can furnish, and this may be true. But the motive for the demonstration and its later bearing upon life are both apt to be overlooked in such pure laboratory work. When once a good problem has been raised in life, it may be well to use all the devices of the laboratory to illuminate and clear it up; but the source from which the problem came, and the final reference of the whole

experiment to its life application, are the things not to be forgotten.

But we have long since learned not to be afraid of complex objects and phenomena in nature study. The squirrel, in spite of its complex structure and fine differentiation of organs, is one of the first animals we study in primary grades. The dog, the cat, and the ox are others. The birds and insects are not of the lowest and simplest forms of animal life, and the flowering trees and garden plants are not simple among vegetable growths. But we study them early in the course.

We must ask ourselves, however, whether this plan of a series of lessons in applied science is feasible. Is it reasonably within the range of children's powers? The final answer to this question must lie in a detailed series of demonstrations, and must successfully run the gantlet of school work in the hands of the usual teachers. But we may gain a few glimpses of the difficulties we have to meet, and of the means of overcoming them.

In the first place, the lessons of this sort for intermediate grades (third, fourth, and fifth) must be of the simple kind. For example, the use of wagon grease for overcoming friction, the grindstone, the proper care of apple trees, the uses of water in cooking, the need for clean hands and finger-nails, dry stockings and clothing, the house cat with its organs and uses, the uses of iron and lead pipe, the planting

and care of seedling trees, the common crowbar and levers, the dangers of flies in the house and means of prevention, life-preservers, the rope and pulley, the derrick, the effects of the use of tea and coffee by children, how cement sidewalks are made, the value of deep breathing, the teeth and their care, growth and structure, weeds in wayside and garden, bathing and its effects, how to keep a cellar clean and wholesome, smoking cigarettes, chewing the food well and eating slowly, good milk and bad, and their effects, a stove or lamp, the compass, a pair of scales, balloons, the lift-pump, the thermometer, a refrigerator. Most of these topics are certainly simple enough and deal with the commonest things. Many of them are treated, however, in grammar grades.

A more serious difficulty arises in the treatment of some of the topics proposed for the upper grammar grades. Some of them may be regarded as simple, like those previously mentioned, as: How to keep a kitchen clean, sinks and traps, etc., sources of a pure water supply for houses and towns, the uses of beer and wine, cleanliness and fresh air in the sick room, the treatment of accidental injuries, fainting, drowning, etc., the value of various gymnastic exercises, dust and some of its dangers, the simple phases of digestion, a barometer, an hydrostatic press, artificial ice making, the circulation of the blood, fire-proof building materials, a clock. Even

the telescope and the steam-engine in their simpler forms are not specially difficult. But the electric bell, the turbine wheel, the telephone, the camera, the electric light, the telegraph and the electric motor, may seem beyond the comprehension of grammar grade children.

The electric light, for example, is regarded as too abstruse for children; but the two main points, how an electric current is generated and how the light is produced at a given point in the circuit, are not very difficult, and in spite of the inscrutable nature of electricity enough can be understood of the conditions of its production and use to make children intelligent about it. Likewise, the generation and expansive power of steam and its simple application are such that the principle of the steam-engine can be understood. The understanding of the complicated machinery of a locomotive engine is not necessary.

At this stage of the discussion there are two ideas which, if clearly grasped, may relieve us of much unnecessary worry.

First, in studying these applications of science to life it is not necessary nor desirable to penetrate into the deeper intricacies of science, that is, to make an exhaustive and systematic study of any topic in science. Our sole purpose is to throw a certain degree of intelligence into these common observations of the uses of science, to awaken an

intelligent interest in them, to prevent, what is too common, a feeling of blank amazement or even indifference in the presence of striking and valuable scientific achievements and objects. Problems too difficult for the children can be turned up anywhere.

There is scarcely a scientific topic, which under the questions of an intelligent child will not soon lead into problems and controversies which expert scientists have not yet settled. In discussing the effects of hurtful bacteria in water and milk, the means by which scientists have found out these germs and the mode of their rapid multiplication, may be briefly discussed and illustrated; but a detailed study of bacterial cultivation and experiment, and an effort on the part of the children to enter themselves upon a difficult line of experimentation, are out of the question. In this case we are more concerned to know how milk and water are contaminated, and the means which scientists have put into our hands for preventing this, than the details of scientific investigation. At the same time the children need to get a quickening insight into the scientific process itself.

In the second place, we are not aiming to give a systematic survey of botany, geology, physics, meteorology, or zoölogy in the common school. We are much more anxious to interpret intelligently the world of man and nature around us than we are to build up a system of classifications or laws such as scientists glory in. After a moment's reflection it

would appear ridiculous that we should ever have dreamed of doing such a thing. In an elementary science course, we draw materials from every science. To require systematic work in each science would be equivalent to dumping the whole high school and college curriculum into the grades. We think that the work of pure science should be delivered over to the high schools and the colleges, possibly only to the latter, and that scientific order and classification should be a wholly secondary consideration in the grades. Why should we seek to cover the field of systematic science in a slovenly way, running over and spoiling in a shallow and trivial manner great things which ought to be left fresh and entire for mature minds? About the only result we shall get out of this procedure, from the children, is a feeling of apathy and disgust. No, let the children be left free to look the world boldly in the face with a natural inquisitive interest, without being burdened with such a load of learning. We believe that these things that surround a child in nature and in human affairs have an abounding interest if we do not try to make them too instructive, too edifying. It might be better to awaken a thirst for classification and system by very small doses, than to make a surfeit of them.

In these practical applications of science to life the centre of gravity is not in the science subjects, but in the problems of human life. If the effect of this phase of science teaching is to give the children such

an impulse that they will approach the wonders of science in the high school with a strong human interest, it will be well. Or if they pass out into life without entering the high school, they will be possessed of that modicum of scientific knowledge which they most need, and with that respect for the achievements of science which will render them more obedient to its requirements.

In what is usually called the nature study of the schools, in the work with plants and animals, the absorption in these objective things in nature is natural and appropriate. The thorough enjoyment for their own sake of the woods and wild flowers, of the song-birds in the groves and hedges, of bees and ants and butterflies, of the fishes, turtles, and rabbits and other dwellers in stream and field — this free and unstinted pleasure in the things of nature is wholly desirable, and our school arrangements should be such as to provide for its steady cultivation. Coupled with this is the mere charm of outdoor life, the glory of the clouds and sunny skies, the undescribed beauty and marvel of ferns and grasses, of flower and bird. These things are wholly germane to the nature study work and should be its best influence.

Without overloading children with a formulated system of science or with technical details, we may allow them to work their own way toward a crude classification of objects and forces in nature which is essentially scientific. The idea of types which dis-

covers such a wide-reaching similarity in large groups of plants and animals cannot fail to lead the children along those chief trails which prove later on to be the great highways of thought in natural science.

Returning to our fundamental theme, the application of science to life, we not only find in public and private affairs this widespread introduction and use of scientific methods and appliances, but the different states and the national government have established schools and experiment stations for the specific purpose of rendering available the resources of science for common life. Schools of agriculture, forestry, mining, veterinary science, horticulture, and architecture have been established in many of the state universities, and the national government has its departments of forestry, agriculture, mining, geological survey, fisheries commission, weather bureau, and patent office through which it seeks to encourage, both directly and indirectly, the use of the best scientific improvements and methods in the great industries of the country.

Not only is this so, but the publications, bulletins, pamphlets, maps, and monographs on special subjects which are sent out from the scientific experiment stations and government offices are the most valuable materials we have for the use of teachers in nature study. The books and pamphlets which have been sent out from the agricultural department of Cornell University, from the universities of Wiscon-

sin, Illinois, and other state schools in the North and in the South, are among the most instructive and valuable aids for teachers in nature study. In the fulness, richness, and appropriateness of instructive material, they are far superior to many of the books that come to us from other sources. This suggests that they have approached the nature study topics in many cases from a better point of view and with a better idea of what is needed for children than the students of pure science who have prepared material for schools.

In the effort to draw our science lesson more directly from life, either in the woods and fields or from human occupations, we find ourselves copying and reproducing in the school considerable sections of the outside world. The children, for example, construct an aquarium and people it with plants, frogs, fishes, and insects, so that they shape up the life conditions of a small pond. Or they lay out a garden in the school grounds, prepare the soil, sow the seed, and cultivate garden vegetables and common flowers. In short, they reproduce on a small scale the partnership of nature with the gardener or florist. In the same way they collect tree seeds and plant a small nursery, or they take care of pet animals, raise chickens and pigeons, and contrive at home or school the conditions favorable to these employments. In the laboratory they get together the tools and materials necessary to make pumps, canal locks, water-wheels, thermometers, siphons, rope

and pulley, and other machines which they can put to work in ways corresponding to the uses of life outside the school. Even such processes in industrial life as evaporation, distillation, fermentation, electroplating, photography, and the glazing of pottery are achieved in the school workshop.

A few important phases of nature and types of human labor can be thus reproduced in or about the school, those especially which have a sort of universal significance, as gardening and fruit growing — things in which nearly all people in different callings can find interest and profit.

There is a strong effort to incorporate these active and practical phases of life into our school programme. We may, therefore, inquire more definitely into their value.

First, the active reproduction of natural conditions requires stronger effort than mere observation. Preparatory to making an aquarium, for example, children must study closely the life conditions in and around a pond and then set to work to reproduce, on a small scale, the same conditions and environment. It is a close study of definite conditions with the purpose of actively reproducing them. If they fail to provide the proper conditions, the plants and animals will not thrive, or will die, so they have a sharp test of their success in understanding and in imitating nature. Every plant or animal must be understood as adapted to its surroundings.

In some respects the most fruitful idea that has come into our nature study in recent years is that of studying any plant or animal in its environment. To see how a duck is adapted by its feet, bill, feathers, structure, and inner organs to live and thrive in ponds and rivers and to migrate with the change of seasons, is most profitable. The same is true of any plant or animal and, in a modified sense, of any machine or process in the industries.

In biology this is named ecology and is now coming into great repute in higher schools. It is the housekeeping notion; how a plant lives and thrives —by a proper adaptation and use of its bodily organs makes itself at home in its surroundings and finds food and protection.

Closely connected with this and, indeed, an expansion of ecology, is the idea of life groups or societies; how plants live together and form a life group in pond or forest.

Now when the children undertake to reconstruct artificially one of these life groups, for example, to make an aquarium, they enter more actively and as participants into nature's work than when they merely look on. This brings out the inventive and constructive activity of children. The motive of imitation and reconstruction lends a powerful emphasis to observation. This is a strong reënforcement of the old idea of ecology.

Where children raise a garden and manage it for

themselves, the same advantage of active, personal participation in nature's work accrues. They must provide the proper conditions of soil, moisture, sunlight, and seed, and by cultivation keep these conditions steadily favorable. Even the care of insects in a vivarium or of wild plants and ferns on the north side of a house has this same element of active, intelligent coöperation with nature. The care of pet animals in cages and pens is a close partnership with nature in providing appropriate food and surroundings.

Back of all this and reënforcing it is the powerful instinct of children for activity. This is of all things the most energetic and noticeable characteristic of children, and, curiously, the one which schoolmasters are constantly overlooking and failing to provide for.

The extent to which this imitative, constructive, and inventive activity of children may be used as a means of vitalizing nature study is made clear by a brief summary as follows. Children find a free vent for such activity in the home and school garden, in making and caring for aquaria, in hothouses and hotbeds, in farm and nursery work, in keeping pet animals and birds, in the many forms of laboratory experiment and construction, in window gardens, in making and handling all sorts of tools, machines, and mechanical contrivances.

In thus showing how much of outdoor and other

motor activity nature study may supply to children, we are almost encroaching upon the domain of manual training and constructive work. In fact, some of the lessons here referred to belong partly to the manual training topics, as, for example, making an aquarium, a cage for pet animals, or seed boxes, tools, and machines. Nature study, however, has a direct interest in these constructions and often furnishes the *motive* for making them, — is in fact a very close neighbor to the work of the manual training shop.

To lay hold of these constructive activities is also to capture and turn to the best use the play instinct of children. In their plays children have a strong bent for imitating the objects and forces in nature and the machines and inventions of men. In the yard they will build up and operate a volcano, a battle ship, a stove with cooking attachment, a fish pond, or an Indian encampment. To turn this play energy into the channels of elementary science is not difficult, and its problems are so much like those which the child sets up for himself that his full participation is secured.

In laying so much emphasis upon the applications of science to life in elementary schools, we are compelled to assume that there are feasible means by which children can be brought in contact with modern life. To a large extent this will take care of itself through the varied common experiences of

childhood at home and in contact with town and country life. But there is one large field in which general intelligence is lacking or is vague and shadowy. It is the field of industrial and commercial life, the very region in which modern science has wrought its wonders. Even well-educated people are not very intelligent about those important inventions and processes which have revolutionized manufacturing, commerce, and agriculture. The changes brought about by these scientific inventions and processes have produced a good share of the turmoil and conflict of our industrial and social life. Society is in a process of constant, painful readjustment to the new conditions imposed by the progress of science and invention. If it can be shown that these things are simple enough in their main aspects for children to grasp, common school education will have to centre a large part of its energy upon these problems. But science must share this work with other studies.

We have in our schools one great study, geography, whose function it is to give an intelligent introductory survey to this special field, — by means of excursions to farms, shops, factories, and commercial centres, to put children in direct contact with these human occupations, with the various work of artisans, tradesmen, and merchants, with typical machines and processes in industrial life. Then by full descriptions the larger facts and relations of our complex economic

life are clarified. Geography, then, is the principal subject to pave the way for that great group of science topics which we have called "the practical applications of science to life." The necessity of geography as a prelude to science studies, as a means of giving this broader practical survey of the whole field, is easily seen. With this work accomplished, science study can settle to its special problems and throw a strong light upon the most important questions of health and sanitation, of special machines and inventions, of scientific processes applied to commerce, agriculture, and manufacture. The simple history of invention and of the evolution of industrial processes will also throw an important side-light upon science studies.

It is very interesting to observe how important and close are these relations between elementary science, geography, manual training, and history. No study can stand by itself or work out its problems unaided.

CHAPTER VII

METHOD IN SCIENCE LESSONS

It seems almost presumptuous to give definite directions as to the method of conducting lessons in elementary science. It is in this subject, if in any, that one is tempted to subscribe to the old dictum that each teacher is a law unto himself, and that common methods are common failures.

This conviction might be strengthened by the startling variety of widely divergent topics treated in science lessons, such as wild plants and animals, inventions and machines, health and hygiene, storms and weather maps, excursions to the woods and fields, experiments in the laboratory, pond life, fishes, frogs, and insects, the bodily organs, digestion, circulation, etc., poisons and antidotes, cooking and house sanitation, a granite boulder, mineral springs, metals and minerals and their treatment, electrical instruments, weeds and harmful insects, domestic plants and animals, the results of using alcohol, physical exercises and bodily strength, contagious diseases, soils and fertilizers, public sanitation in cities, etc., etc.

There are also many ways of getting at the facts, as by direct observation, by experiment and inference,

by collecting and examining specimens, by diagram or model, by pictures, by examining machines and processes, by using the microscope or field glass, by explanation and direct instruction from the teacher, and by consulting books.

Again, the immediate contact with the objects and forces in nature and in the applications of science raises in its acute form the difficult problem of object and experiment teaching, the most highly recommended and the least successfully practised phase of instruction. The freedom and confidence with which teachers, high and low, recommend observational and experimental science, and the modesty and scarcity of those who succeed in such teaching, almost suggest the old fable of the belling of the cat. This is but one illustration of the wide breach between enthusiastic theory and successful practice.

It is, therefore, with some misgivings that we approach the task of giving suggestions upon the method of conducting elementary science lessons. In spite of this unpromising start, we believe there are a few things that can be agreed upon and a few others that need thorough consideration. First among these is the feeling and disposition of the teacher toward this work.

It is easy for us to expect too much from formal method. The atmosphere which the teacher diffuses about him by his own interest and absorption in nature studies is more potent than any of the devices

of method. Indeed, elaborate schemes and detailed plans seem cold, formal, and ineffective as compared with the simple pleasure and enthusiasm of a teacher wrapped up in her work.

While, on one side, too much virtue has been attributed to method, on the other side, too much confidence has been reposed in the mere contact of children with nature. In most discussions of nature study it has been boldly assumed that if children were only surrounded with nature's works, and had their senses assailed by bird, insect, and tree, they would at once respond in full measure to the thrills of nature study. In a few cases this may be true, just as in a few cases children take spontaneously to books; but in the great majority of cases an atmosphere produced by people already interested in nature study is the gentle stimulus that awakens a child's mind to the beauty and attractiveness of the natural world.

It may be observed, in thousands of cases, that children brought up in the environment of country life, with fields, forests, flowers, and birds, show little or no appreciation of these things; but wherever parents, in happy and unconstrained association with their children, notice and enjoy them, the love of nature and a closer observation of her attractions spring up vigorous and strong. Just as the atmosphere of the home, by reading and story and happy familiarity with books, may lay the foundation for the

best acquaintance and real enjoyment of literature, so the atmosphere of the home in its outdoor life, excursions, and rambles may produce an environment in which the love-of-nature sense flourishes.

Teachers may well afford themselves the time to ponder this curious phenomenon, namely, the source from which a deep and permanent enjoyment of nature springs. It is in the balmy sunshine and in the moist and mellow earth that seeds germinate and grow in springtime; perhaps it requires an equally mild and conducive atmosphere to root the child's thought in nature. This may seem to have little or nothing to do with the formal and exact requirements of the school. It is so freakish and unconventional that the teacher does not know what to do with it. But if the child's nature is often of this freakish and unconventional type, and demands an atmosphere rather than studied and prearranged objects, the teacher may well bend to the necessities.

We are inclined to believe that all true nature study will find itself in such an atmosphere, produced by the contact of the teacher's mind with nature, and warming the child's mind to a temperature where he himself feels the glow of interest and appreciation. It is not uncharitable to say that a great deal of our nature study has no such atmosphere, and it is in a gasping condition for the lack of it — not to say stone dead.

An atmosphere is indeed an important condition

of life, and while it is a somewhat intangible thing, it behooves us as teachers not to make our class rooms uninhabitable for lack of it.

If once the interest and activity of children are aroused by these less conventional modes of study, the more regular and systematic work will easily follow. The primary grades seem to be well adapted to this less formal and less intensive study of nature, where a sunny atmosphere among the trees, flowers, and outdoor life is conducive to the love of nature. But this happy companionship with nature should grow with the years, and run parallel with later more strenuous studies.

A true enthusiasm on the teacher's part, however, feeds upon knowledge, and is very inquisitive in the search for it. Everything possible, therefore, should be done to make the right kind of knowledge easy and accessible to teachers.

It is evident that a teacher needs to be progressive and somewhat original. But what equipment of actual, definite knowledge is required? On this point wise people seem to differ, and yet it is hardly possible that any one will object to a teacher's having plenty of knowledge. He should not only have an abundant knowledge, but a pressing desire to get more. In fact, we believe that the urgent need of teachers, for some time to come, will be a larger amount of definite information on those phases of elementary science which they are called upon to teach.

By far the most important problem for those who are trying to help teachers in nature study is not the explanation of a proper method, but the collection of the necessary information around a well-selected series of topics for the grades. Knowledge and method, however, are so closely combined that we cannot discuss one without the other. The ability to select a fit series of science topics for the grades implies a mastery of the principles of method in teaching them; that is, an ability to select the topics that can be taught. One of the curious facts in this connection is that a large part of the knowledge in our scientific text-books is not (directly) of use in the work, while a great amount of untechnical, non-professional, but more practical and interesting, knowledge is greatly in demand. A good deal depends, therefore, upon the kind of knowledge offered a teacher on a given topic, whether it can be used or not with children.

In any and in all cases the teacher needs plenty of knowledge and the enthusiasm for progress in getting more.

The book of nature lies open before the children, and they are to learn to read and to appreciate it. This is by no means so easy as many people have supposed. Under our present system of education nature's book seems more difficult to interpret than learning to read schoolbooks. But a real appreciation even of books is not common. A superficial obser-

vation of nature is common to all. To gain insight into nature, however, children must learn to look beneath the surface and detect the working forces or the hidden law. Nature's secrets lie concealed under the surface of phenomena, and children must learn to uncover the facts and look at the inner workings.

It is generally agreed that children are to find out the facts very largely by their own observation, and even to think out the conclusions to which they point. This principle of self-activity, directed toward real objects and phenomena, requires the teacher to keep himself prudently in the background and partly by indirect means to guide the children's efforts.

To work out this principle of self-reliant effort a great variety of devices is resorted to. One is to plan outdoor excursions in which the children are thrown upon their own resources in observing birds, trees, insects, wild flowering plants, weeds, winds and storms and their effects, rainbows, clouds, and other objects, sights, and scenes in nature. Sometimes the teacher is skilful enough to secure good collections of weeds or insects or seeds which the children have made. Again, objects are presented for direct examination in class. Or experiments with given materials are provided in the laboratory. It may be that a machine or instrument, as a thermometer, pump, or battery, is constructed by the children, is made to operate in the class, and is observed in its

parts and working, for the purpose of getting its principle. In the home or school garden children prepare the soil, plant seeds, and watch them grow into vegetables or seedling trees, and cultivate them. They may even deal with the insects and birds which help or hinder the plants. The children prepare the equipment of nets, boxes, and tools for field work, and mount and care for specimens. In combination with manual training they should construct the simpler machines and apparatus used in science lessons, such as levers, wheel and pulley, water-wheel, boxes for window plants, and kites, balloons, siphons, traps, pumps, a compass, a beehive, a cage, etc. In their drawings and note-books also, the children find free and original expression of their thought.

In keeping a weather record, in caring for pet animals, in observing continuously a pair of robins during the nesting and hatching season, in making a bird or flower calendar for the spring or fall months, the children may be trained to independent and continued observation along given lines. This self-activity appears also in the setting of problems and working toward specific aims in many kinds of lessons, and will be discussed later with illustrations.

But in addition to the knowledge and enthusiasm of the teacher and the self-activity of pupils, the teacher wishes to get at some general basis of action in planning her lessons. The most fundamental idea

in this respect is the *lesson unit*, or the controlling idea around which she organizes her work in dealing with any important topic. It may require one or many days to work out such a lesson unit. The construction and uses of a thermometer illustrate such a unit. The dandelion in its whole cycle of growth, including its adaptations to surroundings, to friends and foes, is such a lesson unit. Fire and the process of combustion is one. A microscope, artificial ice making, the English sparrow, a spring bird calendar in connection with the migration of spring birds, a maple tree in its life history, the grasshopper, the earthworm, the heart and circulation, the electric light, the ox, whiskey and its effects, pure water and how obtained, are such units of instruction.

The heaviest work should have been performed for the teacher by those who select and arrange a whole series of these lesson units for a graded course in school. Supposing now that such a well-selected series has been made and that the teacher has equipped herself with an abundant, suitable knowledge of those topics she has to teach, is it wise to intrude any suggestion in regard to method? Not a few teachers are disposed to say, at this point, that method is superfluous. A good teacher will take care of herself. But a good teacher is one who understands method as well as matter, and we are not helped by such a statement.

It is well to look the difficulties of the teacher's

problem fairly in the face. It is really more serious and complicated than one without experience with children in this sort of teaching would suppose. Were it a matter of merely pointing out so many facts in nature for the children to learn, or of putting certain objects before children to let them find out the facts as best they could, the task would be easy. But it is neither the one nor the other.

We believe that the main question for teachers may be stated in this way: how to get the problems of science before children in such a way as to bring them to the best exercise of their own independent powers in solving them. It consists in shrewd problem setting. It is arithmetic over again, but in more complicated and interesting form. Each object in nature raises a query. The organs of a dandelion or cactus or squirrel are suggestive. They are not merely facts, they are signboards. To one who has learned even the alphabet of nature's book, a cat's claws and teeth are unmistakable signs of its lineage and mode of life. A granite boulder lying on the prairie soil speaks of glaciers and a northern home.

Every plant and animal is a mechanism worked into efficient action by the forces around it. These causes and results can be traced out. In most cases the adaptation to surrounding conditions is very manifest, as with the duck, squirrel, or fish. It is not difficult to get an entering wedge into any science topic by examining some part or organ in a plant or

animal to discover its peculiar adaptation and use. The machines and contrivances invented by men for the purpose of turning nature's forces into useful channels are embodied or materialized problems. To examine a machine, its construction and parts, to find out its mode of operation and use, as a milk separator, stove, or steam-engine, is to work out this problem.

A moderate degree of thoughtfulness on the teacher's part will discover and state such problems as the following: How does the duck, a warm-blooded animal, keep dry and warm while living so much in and upon the cold water? In using a bicycle pump, find out the way in which the air is forced into the tire. In baking bread, what causes the dough to rise so as to be light and spongy? Examine a mole and find out how he is able to burrow so quickly into the ground. As the bees move about from blossom to blossom, what service do they render to the flowers? What kind of physical exercises do boys and girls need to give a healthy growth to all the organs of the body? How can the coddling moth be prevented from damaging the apple trees? What is the construction of a trap to prevent sewer gas from getting into a house? Why is it that a fish can breathe under water but not in the open air? How are the lenses of a pair of glasses made so that some people can see better? What is the effect of drinking cold water while eating? Under what conditions and why do we see a rainbow in the sky? From what

kind of a well may we be assured of obtaining pure drinking water, free from germs?

These are but illustrations of the sort of problems or questions which spring up easily in all kinds of science lessons. To ask questions about objects is not indeed difficult, but to ask the pivotal question, upon which much hinges and which at the same time arouses the curiosity of children, is difficult. It is the business of the teacher, by observation and study, to sift out these important and interesting questions, and to learn how to put them. The objects in nature and the various machines and inventions of men for applying science to life can be best studied with such pointed questions as guides.

Nature study, more than any other school subject, bristles with problems which demand self-reliant thought. The objects themselves are standing problems. In history or arithmetic we are compelled to state in language the conditions of the problem, but a flying bird, a swimming fish, or a spinning bicycle is itself a problem, arousing our curiosity and stimulating thought. It is the business of the teacher to use as few words as possible in getting the problems before the children. Nature does nearly all the talking. The teacher can, however, do a great deal of thinking so as to know where to concentrate the observation and thought of children.

In directing, for example, the observations of children upon the red squirrel, they will be interested

for a while in merely observing their own pet squirrels, or those in the park, or one in a cage; but this kind of shallow observation will soon become tiresome, unless problems are raised which keep the children observing and experimenting along continuous developing lines. If they are asked to find out what kind of food squirrels prefer and what they live upon when in the woods, a field of experiment and inquiry is opened up. How and of what material do they build their nests and what provision do they make for winter? In what ways do the different organs of the body fit them for life in the woods? This question may lead to a close inquiry into the structure and use of the feet and claws, teeth and legs, fur and tail. In fact, the whole activity of these interesting animals and their habits in the woods will come under close survey. What degree of intelligence do they show? This will bring up a number of observations in regard to their storing food for winter, building their nests, caring for their young, ways of escaping from their enemies, their behavior as pets, etc.

Such questions are really significant aims and suggest the working out of a biography or life history. It involves not simply a description of a few points of external appearance; it is rather a full study of the squirrel's home in the woods. So long as new and instructive facts are being unearthed, the subject will not prove irksome to children.

The life history of the squirrel is a survey of its whole habitat from the squirrel's standpoint, with its dependence upon trees and nuts, grasses and herbs, and its close companionship with other animals, birds, and insects. The squirrel fits into its place in nature as a leaf fits its place on the tree. A single animal treated in this particularized fashion furnishes the key to one important method of observation and study. Such treatment checks at the start the easy tendency toward superficial observation and description of external appearances. We grasp at one or more of the significant problems of the animal's life. If we are studying a water bird, we desire to discover how it is adapted to get its food in lakes and streams, and to make long flights. We follow it in its migrations and realize its conditions. If a catfish is the subject of investigation, we desire to interpret its life in the water and its means of living and flourishing there.

Every new plant or animal, every machine or process, presents a new problem, not simply a repetition of old questions. Much of the skill and success of teaching depends upon the ability to approach the topics from the standpoint of problems or significant aims. The setting up of the problems or aims that will cause the children to investigate and think, to collect and interpret facts, is one of the chief demands upon the teacher.

In the course of his observations upon the squirrel,

its organs and surroundings, it is but natural that a child will bring the squirrel into comparison with himself and with other animals with which he is familiar. The boy climbs also, but the squirrel is far more easy and expert. Other squirrels, the cat, and some birds are ready climbers. It is interesting to note the difference in size, color, and habit of the different kinds of squirrels. The little flying squirrel as compared with the red squirrel has distinct advantages in flying, but is much less quick and agile. The peculiar gnawing teeth of the squirrel at once suggest to the boy other gnawing animals, as the beaver, rats and mice, and the rabbit. This may easily lead to a closer study of these gnawing teeth and their manner of growth, renewal, and how they are kept sharp. The contrast with the teeth of the dog and cat and other flesh-eating animals is noticeable, and the reason for this marked difference in the teeth is not difficult to find. In a rough way this difference in teeth shows to children a difference between two large groups of animals, based chiefly upon a difference in food and the means of getting it.

Not all the animals and plants, of course, can be treated with the fulness of biographical detail which is here suggested for the squirrel. Nor is it at all necessary, since one of the aims of nature study is to get broad views of the chief classes of objects and phenomena. These broad views, though crude, are still essentially correct, since the objects or phe-

nomena we study are types. The study of the squirrel, for example, with the natural comparisons which children may make with familiar animals, will give them a tolerably correct notion, not only of all squirrels, but also of the fundamental idea upon which the whole distinct order of rodents is based.

These life histories of animal and plant supply us with those lesson units which we have described before as the important centres of study. Corresponding to these life histories in biology are certain objects and phenomena in physical science (meteorology, physics, geology, and chemistry) whose study opens the door to the large truths of nature in these fields. Such important units of study are the rainstorm, iron as a metal, coal and its origin, the rainbow, the granite boulder, water, its forms and uses, fire and the process of combustion, salt, sunshine, the atmosphere, limestone and fossils, and many others. Such topics should be distributed through the intermediate and grammar grades according to their simplicity and fitness to open the eyes and intelligence of children to the physical world around them.

Still another list of more pronounced units of instruction, and of equal importance, is found in the series of machines and inventions by which man has turned the forces of nature into service, — as the compass, lamp, pump, thermometer, microscope, water-wheel, the clock, the electric bell, the photographic camera, and the steam-engine. Every one

of these, when understood in its construction and relation to natural forces, gives the child's thought a wide conquest over natural things. They are real centres of study, typifying and illustrating in concrete objects the comprehensive laws and energies in nature.

The chief topics to be treated under the subjects of health, physical training, temperance, and sanitation are also well-selected centres of study, and may be handled in a manner similar to that already mentioned; for example, the effects of cooking upon foods, ice, its uses and dangers, structure and care of the eyes, the care of the sick room, kinds and value of gymnastic exercises, the heart and circulation, the ventilation of a house, the nature and effects of alcohol, etc.

We may now summarize a few leading points in the method of treating these lesson units.

1. Every such lesson unit centres in some important truth which is of wide application. A firm grasp of this central idea by the teacher, and a clear perception of its relations to the subordinate topics and facts, is the basis for successful instruction. Then the question arises, How shall children be brought through their own self-activity and thought power to approach and master this unit of study, and how shall they learn to recognize the truth it embodies in its various applications?

2. An aim needs to be set up which points clearly

toward this general truth, and while it involves difficulties still presents an interesting problem for solution. The setting up of such significant aims pointing toward important discoveries and truths is a strong demand for skill and insight in teaching. It points out clearly the road to be travelled in the search for truth, and calls out the self-activity and thought power of students. In an oral or experimental plan of study, the setting up of such guiding aims both stimulates the children and points toward the most important truths to be mastered. In an oral method, such as science teaching demands, it is possible to throw children upon their own resources in the effort to reach the aims set up. A text-book, on the other hand, with its didactic method, works out the problems, giving the solution for the children to learn. In science work children observe, collect facts, trace causes and relations, compare and draw inferences, for the sake of conclusions which are to be worked out by their own thinking and tested by facts of their own seeing. The aim set up should be particular, definite, and interesting, rather than indefinite, general, or abstract. The truth aimed at is first worked out in some concrete setting and afterward seen in its more general application.

3. While any important topic is up for discussion, the first thing to do is to study it so as to determine the facts. Observe it as a whole and in its parts, and the relation of the parts to each other and to the

whole (analysis and synthesis). This process of observation or study presents all the facts clearly to the mind in their concrete setting. For example, in the study of the wild duck as a type of bird life, we would gather the facts relating to structure, organs, mode of life, food, habits, migrations, nesting, and length of life. This is the opportunity for children to be self-active, to observe, to gather facts, to investigate. It is the teacher's chance to guide wisely, to question, to stimulate, and not to be overhasty in forcing conclusions. This is the place, also, for the teacher to give facts which are beyond the experience or reach of the children, and to suggest reference books for their study. If diagrams or pictures or other illustrative devices are needed to bring out the scientific facts, this is their fitting place. The children need also to verify their observations, to render them into some definite form of expression, in word description or drawings. At the close of each important topic, a careful and adequate reproduction of the knowledge gained should be obtained from the children.

4. The typical or general character always involved in such a particular study is seldom seen or realized from the study of a single specimen. We have to look abroad and compare the structure, habits, and life of other wild ducks, and of still other wild birds, and perhaps of other animals, before we can draw general conclusions which apply to large classes. In order to reach general truths in natural science, it is

necessary to make comparisons of many similar and contrasted objects. Teachers often hasten prematurely to these results. For this reason it is almost dangerous to emphasize the teaching of such general truths in elementary science.

A general conclusion may properly spring from an observation and comparison of a number of different specimens of the same class. If, for example, the stomachs of a large number of blackbirds are examined by the scientist at different seasons, and while showing variety of food still point to certain foods as prevailing and common to all, a general conclusion can be drawn in regard to the food eaten by these birds. It is important that these general conclusions, which are the results of observation and study, should be definitely stated in accurate form and fixed in mind. This gives us our law, principle, or rule in logical or scientific form so far as the progress of the study admits completeness.

5. A general law or truth is not sufficiently understood and mastered by working it out inductively and by bringing it to definite and accurate statement for memorizing. For example, we may illustrate and work out a rule in grammar for the agreement of subject and predicate, but to convert such a rule into habit so that the correct form is easily used when needed, calls for frequent and varied application of the rule. We may understand a rule in arithmetic, but many varied and more or less complex applica-

tions are necessary to make it a ready guide in arithmetical work. In natural science, also, the applications of truth and law are infinite in variation and complexity. Every animal is adapted to its environment, with structure and organs suited to its needs ; but we must notice how totally different these adaptations are in fish, fowl, and quadruped before we understand the scope of this law, and are ready to detect easily its variety of applications.

In addition to these essential points in treating topics, there are several phases of instruction in elementary science which are peculiar to that subject. First of these is the outdoor excursion. The management and instruction of children upon an outdoor excursion requires quite a different kind of skill from that of the class room. For outdoor observation and the active, somewhat independent exercise of their powers, children require greater freedom, and this freedom they easily abuse. To keep them within proper control, and yet to allow them that larger scope for action necessary to outdoor studies requires in the teacher both forethought and decision. In this kind of work one soon learns that thoughtful planning is, if anything, more necessary than in class-room lessons. The tendency of children in primary and intermediate grades is to scatter, to chase after any chance butterfly or grasshopper. To give a proper direction and steadiness to their efforts it may be well before starting to point out the chief line of effort

and at times on the excursion to call the children together for concentrated attention, much as in the class room. Again, it may be necessary to scatter out to hunt for specimens desired.

It is to be observed that the social spirit and a pleasant companionship between pupil and teacher are more easily cultivated upon excursions than in the schoolroom. One may also get quite a different estimate of the superior powers of some children upon these outdoor excursions, than in the more conventional and formal school work. On these trips also it is possible to teach a kindlier regard for all living things; the wanton plucking of flowers, breaking of branches and plants, frightening of birds and animals, can be changed into a more considerate, unobtrusive, and brotherly treatment and sympathy.

Nature study calls forth two kinds of observation which, though opposite, should be cultivated side by side. First, is the close, analytic study of one important topic and absorption in this object to the exclusion of the many. It may lead on to a succession of observations following up the early history, development, and relations of a single organism. Other topics are shut out so as to concentrate the more effectually upon this one. Secondly, nature study should teach us to observe many things, to have our eyes wide open and our attention receptive to a variety of objects, perhaps to all the important things that move before our vision. We need, therefore, not

only to concentrate, but to spread our observations. Children go out upon science excursions. The purpose of the excursion should be centred upon some particular kind of tree, as a hickory, or other object. Careful, analytic study of its parts and their functions is necessary, and the close relation to other plants, and to animals should be noted. But, in concentrating attention upon this one object, should they close their eyes to other equally valuable things in their environment? It seems really advisable to combine the two aims to make the excursion count for both kinds of development in observation.

It is necessary in any well-planned excursion which partakes of the character of real instruction, to have some central and controlling object for study, something which supplies the aim of the excursion, and determines its plan and movement. But, as we go on our way toward this object, or in search of it, let our eyes be open and watchful for the multitude of interesting objects and phenomena that may meet us by the way. In this manner, incidentally, we shall gather up a large variety of the most valuable experience, and not be turned aside seriously in our hunt for the principal game.

If, however, we should go out upon an excursion with no particular aim in view, no particular result would follow. It might serve well enough for recreation, but not for the more serious work of instruction.

The observations and specimens collected upon an

excursion may furnish the basis of several later lessons in the schoolroom. These observations are often superficial, broken, and faulty, and the more careful work of the schoolroom may give a much clearer grasp of essential points. The later discussion of things seen upon an excursion may put much greater meaning into the facts observed than the excursion itself.

One main purpose of excursions is to give children an introduction to the world around them, and to teach them what to look for. Their own observations to and from school and at other times should bring together an even larger collection of facts than the school excursions.

The second point to be named is, how to deal with specimens which have been collected for class-room study. One of the serious faults is a failure to bring together a sufficient quantity and variety of material for examination in the class. One must look ahead several days to make provision for this. Children should be encouraged within proper limits to bring in specimens for class inspection. The disposition in the children to take some pains in doing this is a good proof that the study is taking hold of them. The teacher will naturally wish to get out a good deal into the open to observe and locate objects and places of interest, and to collect material for the class. But for the teacher to do all of this is unduly burdensome, and the children are left inactive and helpless in the

very thing upon which their self-activity should be developed. There are many things which children with a little direction and caution can collect, as leaves in autumn, ripening seeds and seed pods, butterflies and beetles, vegetables and flowers or plants from gardens and roadside, cocoons, stones, pebbles and shells, grasses, acorns and nuts, pet animals, and even some such animals as frogs, turtles, and fishes. Children will not develop or continue this kind of activity in observing and collecting unless they receive kindly recognition and attention from the teacher. Many teachers have been quite successful in this kind of nature study who have had no regular period for it in the school programme. But whatever the children bring in, be it chrysalis, milkweed pod, flying-squirrel, clam, pussy-willow, dandelion root, bloodroot, oak leaves, maple seed, or toad, time is taken, at recess or other odd intervals or in lessons for the whole school, to give it thoughtful and sympathetic attention. Many kinds of specimens can be collected and preserved for a longer period, both to furnish a richer material for class study, and to allow a broader comparison and grouping. The mere inspection, arrangement, and careful grouping of the specimens as they are brought in gives an excellent kind of study. For example, the collection of the blossoms, seeds, or pods of box elder, elm, maple, ash, locust, birch, catalpa, and other hardwood trees, or the cones and seeds of

evergreens, or even the young seedling plants of different trees, is thus valuable and instructive. Teachers are sometimes careless or indifferent about the things brought in by the children. These are allowed to accumulate till they have to be cleared away, and are thrown out or destroyed. This is a direct discouragement to children from the right lines of work.

One of the pitiful things in nature study is to witness a teacher with twenty children trying to make a nature lesson out of a single dandelion blossom, or what is even worse, to see her flying about just before the lesson, hunting for something to show the children. Even where an abundance of specimens is at hand so that each child has several to examine and work with, as, for example, in dealing with the rootstocks of perennials like the dandelion, yellow dock, sweet clover, etc., it requires judgment and skill to direct wisely the observations of children. Even to have the specimens ready for prompt distribution is no slight matter. It would seem trivial to mention such items if it were not so seldom that we do these things promptly and neatly. In fact, neatness and orderliness in the care of specimens and in the arrangement and distribution of materials is one of the best opportunities the teacher can have for developing in herself and in the children the right habits. To tear up and scatter specimens about in a slovenly manner is bad housekeeping and bad education.

Sometimes the teacher is overkind to the children in showing them what she sees. It is better to keep one's self in the background and to let the children hunt for themselves. It is often well to give direction to observation by a question which is as clear and non-committal as possible. Instead of pointing out to the children that the internodes on the corn-plants they are examining are shorter near the ground, a question may be raised as to the length of the internodes along the stalk, and the reasons for what they see. Children are most of all interested and awakened by what they themselves see and discover, and their self-activity should be encouraged to the utmost so long as they do not run off too much to frivolous and unrelated things. As in learning to swim, they should be left to their own action as much as possible, with suitable suggestion and occasional timely aid.

In making experiments in the laboratory (in physics and chemistry and their applications or in plant physiology) the same forethought should be exercised by the teacher in providing the necessary apparatus and equipment for successful experiment. Children, of course, can often construct or help to construct simple apparatus, as kites, balloons, sun-dials, suction pumps, wheel and pulley, in installing batteries and wires, in arranging materials for simple chemical reactions. The laboratory is the place for them to handle the materials, and to experiment under wise direction. Simple home-made apparatus,

prepared by teacher and pupils, is better than elaborate equipment.

We are here upon the debatable ground between natural science and manual training. Wherever simple constructions are made or experiments performed by the children, requiring some degree of thoughtfulness and skill in putting materials together, manual training is actually present in its best form. It seems quite admissible that some of these constructions, requiring the working out of definite problems, should be turned over to the manual training phase of instruction. Where the schools do not provide for manual training this will have to be done, so far as possible, in the science studies. But a very interesting problem of correlation is here to be worked out. In our "Special Method in Manual Training and Constructive Work" a solution of this problem is attempted.

In the study of machines and inventions in each case a problem is offered for solution. How does a common oil lamp work? The result is evident, but what part does the oil, the wick, or the chimney perform in producing the result? Show the whole movement from the oil to the light and its effect. What is the arrangement for securing fresh air and why is it necessary? Study a windmill and see how all the parts are built to produce the final result of pumping water or grinding grain. This in most cases demands a strong exercise of close observation

and thought. In many machines, as a pump, steam-engine, or heating plant, some of the important parts are concealed. After watching the external working of the pump, it may be necessary to take it to pieces to find the construction of its inner parts. To better understand a door lock or a milk separator, they should be taken to pieces and closely examined. Sometimes a blackboard diagram which shows the interior parts and working of a machine is better than anything else. It is an interesting question whether a diagram illustrating the action of a steam-engine is not better than the machine itself, when combined with questions and explanations by the teacher. It may be well first to examine the simplest form of the steam-engine we can find and interpret it as far as possible. This will at least bring to light one or two of the main problems. We may then resort to a diagram to show the production, action, and result of the steam power. We meet with a similar difficulty in studying the life processes in plant and animal. The movement of sap in a tree, the circulation of blood in an animal, are often illustrated in the books or on the blackboard by a diagram. The diagram is often the easiest and simplest method of presenting the fundamental idea, especially when the inner parts of the process are not visible. This is true, for example, in the process of distillation, of the blast furnace, of the hydraulic press, etc.

There are even more difficult and intangible processes in nature, illustrated by the waves of light and sound, and what we call the electric current, which can be best conceived with the aid of diagrams and drawings in connection with experimental apparatus.

It is not too much to say that the teacher in nature study should be as expert as possible in the use of all the graphic means of illustration, as pictures, sections, working drawings, outline diagrams, and models. In many cases these are merely aids to the imagination to put things together and to conceive the essential idea. Many of the text-books of science contain these excellent diagrams, which the teacher should learn to construct readily on the blackboard. Many also of the semi-technical and popular treatises on natural sciences, especially those which show the common applications of science to life, have excellent pictures and explanatory diagrams.

It should never be forgotten that the ability of the children to construct these diagrams on the blackboard and to explain them lucidly is one of the best final tests of the mastery of machines and problems. A good example of the value of pictures and diagrams is found in the illustrations of the linotype machine in "Progress of Invention in the Nineteenth Century," pp. 166–169; also the diagrams for modern sanitary house plumbing and street connec-

tions, pp. 256 and 257. Many excellent illustrations are given in this and in other popular scientific books. Very crude, graphic methods of homely illustration are constantly serviceable in teaching a class.

It is a disadvantage to both teachers and pupils to have too much apparatus and manufactured illustrative material, though some things are indispensable. In spite of the fundamental realism and direct contact with objects in science study, there are still a good many devices necessary to objectify and make tangible the teachings of science. Many things cannot be seen, but must be reasoned out. The shape and movements of the earth, for example, must be typically illustrated. The atomic theory has to be thought rather than seen; the circulation of the blood (in spite of the frog's foot and microscope) must be explained by diagram or manikin. At almost every step our thought goes farther than our sight, and yet needs constantly to be checked up and verified by the actual.

At this point an interesting question comes up as to the value of the *imagination* in science studies. The tendency to exercise the imagination in science is strong in all grades, from the primary school up through the university. Primary teachers, especially, are full of imaginative suggestion to the children, and the children themselves take to the imaginative forms of thought as a duck to water. The baby seed in its cradle is waiting for the warm sunlight to call it up

above the ground. The papa and mamma bird take care of their little children. The pussy-willow has its warm fur coat in the chill of early springtime. The snow is a blanket that covers up the flowers in winter. A child thought the half-moon was only half buttoned into the sky. Such fanciful suggestions are innumerable in the instruction of children. Some of the strict construction scientists are very much opposed to this imaginative tendency in science work. The notion is that science is, first of all, valuable for its adherence to the *real*, for its exclusion of the fancy. Superstition, guessing, hearsay, careless inference, fairy tale, are all shut out, and we are kept close to the unadorned, incontestable facts — the things admitting of no equivocation. Natural science is, of all studies, the one to free us from superstition and convince us of the all-prevalence of law.

It is a curious fact that children, primary teachers, and poets refuse to be bound down to the plain realities. In order to understand nature they fall back upon the aid of the imagination. In the fall they think of the tree as wrapping up its tender buds in scales; a caterpillar was described by a three-year-old girl as a worm with a fur coat on. Teachers who have to deal with children fall very easily into such forms of description as are best understood by the children. But our poets also, who know how to give distinctness and point to truth, are full of such imaginative touches.

"Every clod feels a stir of might,
An instinct within it that reaches and towers,
And groping blindly above it for light,
Climbs to a soul in the grass and the flowers."

"Laughed the brook for my delight,
Through the day and through the night,
Whispering at the garden wall,
Talked with me from fall to fall."

"The little brook heard it and built a roof,
'Neath which he housed him winter proof;
All night by the white stars' frosty gleams,
He groined his arches and matched his beams."

It would be impossible to quote ten lines of the best poetry of nature without just such beautiful imaginative touches.

One of the professors of natural science in a large university, in lecturing before a body of a thousand teachers, asserted "that parents, teachers, writers, and educators had combined of late into a syndicate for teaching children lies." This refers directly to the use of the imagination in nature studies so prevalent, especially among primary teachers. The question is whether the imagination can be dispensed with in nature study, either by the child or by the trained scientist. The same lecturer spent an hour with his students describing the different theories of heredity. The question may be pertinently asked, What is such a theory? And the necessary reply is that a theory is not a fact nor a collection of facts

of observation, but an effort of the scientist, through his reason and imagination, to give meaning and unity to the facts. Theories are often found to be false, but the effort to test them and to prove their falsity leads closer to the truth. It is by setting up and testing hypotheses that the scientist makes discoveries.

To shut out the use of imagination in nature study is doing violence to a child's nature, for all his thoughts naturally assume imaginative forms in early years. How flat and insipid would any nature study be which tries to bind down a child's thought to what is manifest to the senses! He can't see the plant grow. He only sees that changes have taken place, and reason and imagination must help him to the rest. It is on the poetic and æsthetic side that nature makes its strongest appeal to children. Many of the greatest poets have been the closest and most faithful observers of nature. Goethe, the Shakespeare of the Germans, ranked among the greatest scientists. Emerson, Burroughs, Thoreau, and Bryant are poets of nature, and observers also in the sense in which we wish to see children trained to observe.

It is certainly the business of nature study to teach children to observe accurately and to have an honest respect for the facts; but in reaching forward to the laws and unities, in interpreting

the phenomena of organic and of inorganic matter, the imagination is indispensable. Facts and observations are often only stepping-stones to the child's thoughts, the scaffolding by which it constructs the higher forms. Figures of speech and poetic analogies, which both teachers and pupils use so often, are the very soul of good instruction in natural science as well as in other studies. As Burroughs studies the birds, his imagination puts a human sympathy into their lives which is better for children than the facts and skins delivered to us by the dissecting knife and the taxidermist's skill. Science study is something more than a collection of lifeless memoranda.

Some primary teachers seem to outdo the children in finding sentimental and fanciful resemblances in nature. They deal in baby talk and strain after impersonations and fanciful analogies. This is only a good thing carried to a ludicrous extreme. But any one who walks with children among birds and trees and butterflies will be taught to appreciate their impersonations and fanciful descriptions, for these are based upon the apperceiving experiences of the children. The exact technical terms of science are unknown to the children, and should not be forced too soon upon them. They describe with much originality and acuteness and nearly always in figurative phrases.

Professor Tyndall, in his essay on the "Scien-

tific use of the Imagination," treats this subject as follows: "How, then, are those hidden things to be revealed? How, for example, are we to lay hold of the physical basis of light, since, like that of life itself, it lies entirely without the domain of the senses? Now, philosophers may be right in affirming that we cannot transcend experience. But we can, at all events, carry it a long way from its origin. We can also magnify, diminish, qualify, and combine experiences, so as to render them fit for services entirely new. We are gifted with the power of imagination, combining what the Germans call *Anschauungsgabe* and *Einbildungskraft*, and by this power we can lighten the darkness which surrounds the world of the senses.

"There are tories even in science who regard imagination as a faculty to be feared and avoided rather than employed. They had observed its action in weak vessels, and were unduly impressed by its disasters. But they might with equal justice point to exploded boilers as an argument against the use of steam. Bounded and conditioned by coöperant reason, imagination becomes the mightiest instrument of the physical discoverer. Newton's passage 'From a Falling Apple to a Falling Moon,' was a leap of the imagination. When William Thomson tries to place the ultimate particles of matter between his compass points and to apply to them a scale of millimeters, it is an exercise

of the imagination. And in much that has been recently said about protoplasm and life we have the outgoings of the imagination, guided and controlled by the known analogies of science. In fact, without this power our knowledge of nature would be a mere tabulation of coexistences and sequences. We should still believe in the succession of day and night, of summer and winter; but the soul of force would be dislodged from our universe; causal relations would disappear, and with them that science which is now binding the parts of nature to an organic whole" ("Half Hours with Modern Scientists," p. 250).

The question as to what kind of note-books and drawings children shall make and keep is important. Even in primary grades, in making a weather chart and in drawing crude illustrations of objects, the children make much use of brush, pencil, and chalk.

In intermediate grades the blackboard is regularly employed in illustrating the parts and arrangements of flowers, seeds and plants, insects and birds. Upon excursions it is well to get the children early to note down important points, new names, and to sketch in their note-books objects of special interest which cannot be transferred to the schoolroom. This sketching intensifies observation and becomes an interesting activity. From the fourth grade on, it has proved useful in some schools to keep in a good composition book a brief outline of all the topics in nature study

of the year. This holds both teacher and pupils to a certain definiteness and orderly system which prevents a great amount of scattering and incoherent work. Grammar school pupils should be held to a somewhat strict account in their note-books of the topics treated upon excursions and in class. Drawings to illustrate machines, processes, landscapes, natural phenomena, and phases of plant and animal life are a natural outgrowth of such instruction, and should be incorporated into their proper places in the note-book. The power to describe and express in written form what they have observed is a phase of elementary science work, especially in the grammar school, which is worthy of special emphasis.

The question to what extent teachers in science lessons should set before the children facts not present to observation brings up an interesting problem. It has been usual to say that nature study is object study and should be held to the real. But many subjects reach out far beyond the possible observations of the children. The wild duck cannot be followed toward the pole except in imagination. Of scarcely any animal can we observe its whole life history but rather sections and parts. In dealing with weather topics, public and private sanitation, the constructions of important machines and processes in manufacture which illustrate the applications of science to life, we may be able to illustrate some of the facts, but many of the most important things

necessary to a clear illumination of the subject must be drawn from a region beyond the experience of children. The unit of instruction which needs to be cleared up as a whole must determine to what extent these outside facts may be drawn upon. Even in the study of the squirrel or the robin some of the facts observed can be best understood in the light of facts which the teacher has seen elsewhere or has obtained from reliable books or observers. As in geography or history, the teacher must determine what facts are needed to give unity and the best comprehension of the subject.

The children themselves may even make a very good use of some of the better books of nature study, — "Squirrels and other Fur Bearers," "Wild Neighbors," "Birds and Bees," "Secrets of the Woods"; and yet, as I look over a considerable library of nature study books, I do not find many that children voluntarily read. The life and observations of children in fields and woods should awaken and interest them so that they will more readily read and enjoy such books; and, on the other side, the best nature books are likely to make children more interested in natural things.

One of the most important considerations in elementary science as in other studies is the proper connection of lessons in any grade with those that precede. The general plan and arrangement of the topics in the course of study must provide largely for

this connection and sequence. But in the teaching of particular lessons there are great opportunities for securing this connection and for building up coherent bodies of experience. Nearly every science topic brought up in later studies can find firm footing in topics previously studied in the grades, and it is the business of the teacher to hunt out these earlier subjects and bring them into sharp review. In a previous chapter we have noticed that the elementary science lessons naturally group themselves around a few centres, the home, the school, the playground, the country life, garden, etc. Nearly all subjects of nature study have sprung from these centres and are already closely related to one another. The recurring seasons bring many of the same objects previously studied prominently into view. The woods or fields in spring are visited again under similar conditions, and the new plants and flowers studied are in the same environment as the old ones and illustrate many of the same ideas and laws that we have previously worked out. The old observations and experiences constantly weave themselves in with the new. The idea of the type and of type processes in nature and also in machines and human contrivances is so wide-reaching that we can scarcely name a topic in later studies that does not suggest many others that have been studied before.

The opportunity which is here offered to gather up the threads which have been dropped, to refresh old

experiences, to suggest comparisons, to even dig down for hidden treasures which have been lost, should not be neglected. The course of study should enable the teacher in a middle or upper grade to discover what related topics have been treated in earlier years; but even in the absence of this, questions should quickly bring them to light. In studying the heart and circulation in eighth grade is furnished the best chance to review digestion, respiration, and several other topics on health, also the treatment of persons accidentally cut or injured, foods, physical exercise, etc. Such reviews in connection with later topics are of great advantage in several respects. They give a new meaning and relation to the old topics, they help to quickly interpret the new subject and, as in the case just cited, they show the important interrelations and dependence of the different organs of the body.

The importance of this kind of retrospective work, and of regarding each later year's lessons as a means of better organizing and consolidating all the earlier studies, can scarcely be overemphasized. That teachers have failed to grasp this mode of instruction and have taught each lesson or topic as if it were uncompanionable, without friends or comrades anywhere, is due to several causes: first, a lack of a definite course of study in elementary science; second, a feeling that each year's work was a distinct and independent stage; and third, the conviction that

the method of knowledge is the mere acquiring of facts and storing them in the mind. There is a failure to see that the important ideas run through the whole course, repeating themselves from time to time in varying forms, and that to organize the facts along these central lines is to illuminate and unify the fields of knowledge.

A glance at our proposed course of study in elementary science in Chapter IX gives at first an impression as of a miscellany. But the tendencies toward unity and simplicity, if followed up, will give, we think, a connected body of knowledge.

There is still another means of bringing connection and unity into our scientific knowledge almost equal to the one just mentioned. It is found in tracing the very close connection of the science topics to geography, manual training, history, and a few other studies. Without going deeply into this, for it has been discussed more fully in the "Special Methods" in geography, history, and manual training, we may at least give a few illustrations.

In a great many geography lessons we reach the point where we cast longing glances over the line into the fields of science, which can alone answer the questions that geography raises. The fossil remains in the rocks, the deposit of coal, kerosene, metals, etc., the earth as one in the family of planets (what about the rest of the family?), the plants and fruits of the soil studied in geography, the processes

and machines of mining, manufacture, and commerce, lie half in the fields of geography and half in that of science. Geography carries these topics halfway and stops short. The most interesting part of the story is to be continued on the other side of the line.

This overlapping of the fields of knowledge has been making the schoolmaster much misery of late years. Just as he was getting all the subjects nicely blocked off and snugly tucked away, each in a safe place by itself, or at least with a Chinese wall around it, the levellers with their doctrine of correlation come along and obliterate all the walls and fences. Correlation seems, in other words, to be a sort of pedagogical gunpowder which is designed to knock down those heavy walls which the schoolmaster, with so much expenditure of time and labor, has built up.

But the division lines between the studies are not obliterated. The walls of separation are indeed taken away, and the traffic lines now run directly across them. Just as railroads and rivers pass across state boundaries, carrying traffic to and fro, bringing the states into closer unity without disturbing the integrity of the separate states, so correlation is beginning to build its great traffic routes of association, binding all the studies into a closer compact.

For the teacher to call attention to these important cross connections of nature study with geography, manual training, etc., is to help the children

to bind together those things which belong together in their minds.

Manual training, like a Russian giant, is laying hold of new territories and constantly encroaching upon the old studies. The making of apparatus for science excursion and experiment, the preparation and skilful use of the tools, machines, and materials necessary to studies in botany, zoölogy, chemistry, physics, and astronomy, and still more the construction of traps, pumps, and devices for illustrating the applications of science to life — all these are really forms of manual training. The more closely science and manual training stand together, the more ably they will support each other, and the better will be the result. For manual training is simply an emphasis of the power to use knowledge. It has been the boast of science that it brings children up against facts and realities, but manual training goes a step farther and teaches children the simple arts of moulding and shaping these realities, these material things. We are not concerned at this point to draw the line between science and manual training, though it must be done in arranging a full course of study.

History and drawing have likewise many points of close contact with nature study, but this will hardly require illustration in the present treatment.

From the standpoint of the teacher in the class room these correlations of nature study with other subjects are significant because they give added

meaning and life to the lesson. When the science lesson explains the turbine wheel, the process of distillation, the vacuum pan, or the forms of crystallization, it throws light upon earlier lessons in geography which, if recalled and brought into connection with this topic, make the child feel that he is getting his bearings and is seeing the great connections between things. This kind of teaching of course requires thoughtfulness and many-sidedness in the teacher, but it also produces these same qualities in the pupils.

The teacher, therefore, who is looking for connectedness and unity in his elementary science course will see to it that the varied topics of the science course are clustered around a few important centres of the child's own life and activity, that the actual class-room instruction upon any given topic shall not fail to reach back into the earlier lessons that are properly associated with it, and that the strong cross connections of science with history, geography, manual training, and other studies be allowed their full natural influence upon a child's thought.

CHAPTER VIII

ILLUSTRATIVE LESSONS

The Chicken

The following lesson was worked out by Mrs. Lida B. McMurry in the primary grades: —

In the story of "The Four Musicians," when they stopped in the wood for the night, where did the rooster settle down? (In the top of a high tree.) How did he get so high? (He flew to one of the lower branches, from there to a higher one, and so on.) Why do you think so? (I have seen chickens fly up into trees, and that is the way they always did it.) Why didn't it fly directly to the top of the tree from the ground? (Its wings are not strong enough to carry its heavy body so far without stopping to rest.) Does a chicken have much flying to do? When does it fly? (To and from its roost.) Where does it roost? Where did the rooster roost after his good supper in the robbers' hut? Have you seen chickens fly at other times than those just spoken of? (Sometimes, when they cannot get through a crack, they will fly over a fence.) How? [Children repeat their observations.] They usually fly to the top of the fence, light there, then fly down on the other side. Why

do they make so much noise with their wings? (It is such hard work.)

Do you know what is sometimes done to chickens to keep them from flying over fences? (Their wing feathers are clipped on one wing.) How does this hinder them from flying so high? (They cannot balance themselves.) How does a chicken fly? (By beating its wings against the air.) You can raise your heavy body a little way from the ground by pushing down on two posts driven into the ground. A bird has no posts to push against. What does it press against? (The air.) That is always handy, too. [By the use of a light fan, fanning downward and outward rapidly, the children become conscious that there is a resistance of the air.] We do not wish to go deeply into this subject. Perhaps it would be wise not to touch upon it at all, but usually the interested children bring up the question and force some explanation of *how birds fly*. The motions of the wings made by the chicken in flying — are they slow or rapid? In raising its wing why does not the air above push the bird back? The chicken does not raise its wing straight up; it cuts through the air with the front of the wing, *so* (showing with the fan.)

You have seen the wing of a chicken on the dinner table and it looks much smaller than when on the chicken. Why is that? (It has the feathers off.) [If possible, the teacher should have a gentle hen in the

class, also the wing of a dressed chicken, and a wing with feathers upon it. Compare in size the two wings.] Is this hen going to fly now? How do you know she is not? (Her wings are not spread.) The teacher extends and contracts gently the wing of the hen a few times. Does that make you think of anything you sometimes see? (A fan.) When does the chicken close its fans? When it does not wish to use them in flying? Why does it not keep them stretched out all of the time? (They would be in its way.) When? Can you show with your arms how the hen closes her wings or arms? What does she do when she wishes to fly? [Children relate their observations.] Show how, starting with your arms in the position of the closed wings. This will require close observation. [Call attention to the position of the thumb or forefinger in the dressed wing.] Do your arms now look like the chicken's spread wing? (No, the skin that holds the two parts of the hen's arm, or wing, together, is wanting in our arm.) What, then, can you do with your arms that the hen cannot do with hers? (Stretch them out straight.) Picture on the board John's arm stretched out. Beside it picture the dressed wing stretched out. What is this wing made of? (Skin and bones and muscle.) Can you think of any reason why it may be well that there is no more meat on it? (The meat would make the wing heavy. She would tire holding out a heavy wing in flying.)

But the hen has, besides the skin, bones, and muscle, what? (Feathers.) Do these help or hinder her flying? (She spreads out these feathers and strikes against much more air than the naked wing could press against. She could not rise at all with the naked wing.) Let us look at one of these large wing feathers and see if we think it is the kind the chicken needs for flying. Lift it. (It is so light that I cannot feel its weight.) Does the chicken need light feathers? Why? Is this feather straight? (No, it curves downward a little.) Is this well? The feathers hold the air under better than they would if they were flat. [They will notice the difference in pressure of a concave and a flat fan.] How many of these long feathers? Does it need so many?

Pull a feather from this wing, Elta. [The feather comes only after hard pulling.] Is it well that they are fastened so tightly? Why? We will look closely at these feathers. This middle part is called the shaft. Each side is called a web. Is the web of the same width on both sides? (Notice how the feathers are arranged on the wing.) The narrow web of one covers the wide web of its neighbor. Only one side needs to be long and the chicken wishes to have as light wings as possible, as we have said before. Can you think of any reason for having the narrow web over the wide one? Examine the wing. Would it do just as well to have the wide web over the narrow?

Notice one little piece of the web. That is called a barb. Separate carefully these barbs. (They cling closely together.) After you have separated them, smooth them down. What do you notice? (They cling as before.) Hold the feather up to the light as you slowly separate these barbs. What do you see? (Each barb has little teeth on both sides. These teeth fit into those of the barb next to it.) Is that well for the chicken? (Yes, if the feathers let the air right through, it would leave nothing to press against and the chicken would not rise.) Of what use are these feathers? Above these, what? Can you think how else the chicken is helped by having feathers that shut out the air? (Its body is kept warmer.) How are the little chickens helped by such feathers? (The wings cover the little chicks at night and at other times, and so keep them warm.)

Are all the barbs on the hen's feathers hooked together? [Examine one of the small feathers.] On which part of the feather are the barbs hooked together? (On the part that is on the outside of the chicken. The part that is covered is softer — more like down.) How are the small feathers arranged on the hen? (They all point backward from the head, and grow one over another like the shingles on a house, only closer together. The barbed part is on the outside.) Is this well for the hen? Why? (It makes a very thick cover, keeping out the cold, and

also sheds the rain quite well, the rain running off the end of one feather on to the next, and so on until it drops to the ground.) Have all the feathers barbs? Where do you find feathers without barbs? Notice how a hen stands in the rain. (With her tail drooping, as if to let the rain have a chance to run off by the way of her tail feathers.) In what other way is the chicken helped to keep dry in rainy weather? Have you noticed what a hen sometimes does during a rain? (She oils her feathers so they will shed the rain.) Will oil shed water? How do you know? Have oiled paper in the class. Pour water on it and see what happens. Where does the chicken get the oil? (From a little sack just above the tail.) [Show on dressed chicken.] Where does the oil come out? How does the hen get it out? (With her bill.) How can she reach away around there with her bill? (Her neck is long and limber, and she can twist it around easily.) How does she get the oil out? (Presses down on the sack with her bill, and it comes out as does the juice when you press on an orange in which you have made a hole.) How does she carry the oil to the feathers? With her bill? How put it on the feathers? (She passes each feather which she wishes to oil between her two mandibles.)

Her bill is the finest comb the hen has. But her hair combing is no queerer than her bath. Did you ever see a hen bathing? No? Did you ever see a

hen in an ash pile or in a pile of dust fluttering around? Just what did she do? [Children find out if they cannot tell.] This is her bath. Does she seem to enjoy it? What does she do when she is through her dust bath? Change her clothes? No, but she shakes out the dust and preens her feathers. (Smooths her old dress.) How? Does the hen never change her dress? Have you not seen many feathers lying around the hen-house? Did something pull them out? Do they usually come out easily? How does this happen, then? (Little by little she is changing her dress. An old feather falls out and a new one grows in to take its place. Sometimes a hen loses the whole of her tail at one time.) When does this changing of dress happen? (Late in the summer.) Is this a good time? Why? How do the little new feathers look when they first come in? What do we call them? (Pin feathers.) Examine these carefully if they can be found when this is studied. Why does the hen need to change her dress at all? (The feathers wear out and become much mussed.) Is there any order in shedding her coat? [When one wing feather comes out, its mate on the opposite side is said to fall out also. Watch and see if this is so.] Are the dresses of the little chickens like their mother's? (No, the chickens are covered with down.) How is the down different from feathers? Children see. (Down has no shaft and web.) Before going farther the children tell

what they have learned about chickens' flying, their wings, and the feathers.

Have any of the other animals that we have studied feather coats? What kind of coats did they have?

Where did we find the rooster in our story roosting at first? Where later? Where do the chickens that you know roost? Why should they leave the ground? (Sometimes the ground is cold and damp. When on a high roost the chickens are not so apt to be disturbed or killed by rats, skunks, dogs, etc.) How do they hold on to the roost? [If no one in the class can tell, the children may be given time to find out for themselves by watching the chickens at home.] (Its three front toes curve around the roost in front — *this way* — [showing with the fingers] while its hind toe reaches around behind and steadies it.) But when the hen is asleep will she not stop holding on and fall off? Notice a hen as she raises her foot in walking slowly. How do the toes look? They curl up very much as if holding to a perch. When do her toes spread out? (Only when her feet come down on the flat ground. At other times her feet are in a position to hold on to a perch. And the weight of her body only tightens her hold.) When on the perch do the hens stand up all the time or do they sit? Find out. Do they close their eyes?

At what time of day do chickens go to their high beds? (About as soon as the sun goes down.) Do

we hear from them at all during the night? (The old rooster crows occasionally.) How early in the morning do chickens get up? (In the summer time, as soon as it begins to be light. In the winter, they, like ourselves, hate to get up into the cold, so they stay on their beds sometimes until after sunrise.) Can you think of any other reason why they do not get up (or get down, rather) earlier in the winter? They have not so much work to do. There are no bugs, or worms, or vegetables to which they may help themselves. What do they eat in the winter time? Where do they get it? Did you ever notice how the hen eats the corn? [The teacher can feed the one she has at school.] What did she do? (Picked up the kernels very fast with her bill.) What kind of a bill has she? (It is hard.) Is that well? Why? (It is strong.) Why does she need a strong bill? (It is pointed.) Why is this a good thing? The upper mandible is curved. Is it better so? Why? Notice how the forefinger is curved in picking up a pin from the floor. Notice the shape of the lower mandible. What do you think of that? The bill has sharp edges. Is this well? (Yes, the chicken can cut off pieces of leaves, grass, etc., very easily with such sharp knives. She can cut them off as fast as she can swallow them.) What other animals did we find swallowing food very rapidly? (Cow and sheep.) But was this the last we heard of this poorly chewed food? (No, they re-chewed their grass, hay,

etc., as a cud.) Have you ever seen chickens chewing a cud? (They do not.)

Let us see if we can find why a chicken does not chew its food. With what do we chew our food? (Teeth.) What kind of teeth has the chicken? Very carefully open the hen's mouth and the children will see that she has no teeth. Then why does the chicken not chew its food? What becomes of the corn that it takes into its mouth? (It swallows it.) How many have ever watched the dressing of a chicken? Did you see its crop? Feel *right here* on our hen. That is its crop that you feel. The food that it swallows goes first into that. I have here the crop of a chicken. We will open it and see what we find. [There is nothing repulsive about this to the children, as all have seen dressed chickens, and many have watched the process of preparing them for the table.] Now the corn, grass, etc., stay in the crop until they are very well soaked, then they pass on to the gizzard. Do you know the gizzard? It is the chicken's stomach. Here is one. Feel of it. It is very thick and tough. We will open it carefully. [Peel so as to leave the inner sac intact.] What kind of a coat is this outer coat? (Strong and thick.) We will open the inner coat. What do you see? (The food ground fine and some pebbles.) Take hold of this inner sac. (It is tough and elastic.) Where is the door through which the soaked corn comes into the stomach? When it gets inside of

this mill it is tossed back and forth with the stones and becomes very fine, as you see. From this food the chicken's blood, flesh, fat, and feathers are made, and its muscles and bones are repaired.

Name other things that the chicken eats in the winter. And in the summer time what? Where do they find the bugs, spiders, etc.? How catch them? [Children watch chickens and see.] Where do the chickens find the worms? (In the ground.) How get them out? (With their sharp toes.) Did you ever see a chicken scratch for worms or seeds? How did it do the scratching? Then when it found something good to eat what did it do? (Picked it up quickly with its bill and swallowed it.) What if a hen with her little chickens finds something good? (She calls her little chickens with some quick clucks and lets them have what she has found. When *they* get over being hungry she feeds herself.) How can she see the little seeds and bugs? (She has bright eyes.) Where are they? Is this well for her? Why?

We have spoken of the hen's food, but not of her drink. What does she drink? How? (Puts her bill into the water and then raises her head.) Does her bill move when in the water? What is she doing? (Filling it.) Why does she raise it? (To let the water run down her throat.)

How do you think the rooster that belonged to the band travelled? (Walked.) As we said before,

chickens fly but little. On what do they walk? (Their toes.) About what other animal that walks on his toes have we spoken? (The shepherd dog.) Does the rooster walk as the shepherd dog does? (No, it walks on the toes of *two feet*, the dog on the toes of four feet.) On how many toes does the chicken step? (Examine tracks in snow or mud.) Does the hind toe help any in walking? Of what use is it? Are the front toes all of the same length? Which is the longest? Why is it well that the chicken has long toes? (If his toes were very short his body would more easily tip over.) Are their long nails in the way when walking? Why not? Look at the base of the front toes. (A little web is there.) Why? What keeps their toes from being hurt by stones, rough dirt, stubble, etc.? (They are covered by tough, hard rings.) This long part from the toes up to the joint is the chicken's heel. Is the heel naked? No, covered by plates of tough, hard skin. Have you ever seen any chickens with feathers on the heel and toes? Notice how tiny are the little chicken's toes. Can they get around well?

Did you ever call the chickens to feed them? Did they hear you? Then what did they do? How can the chickens hear when we call? Have they ears? Did you ever see them? [Very likely the children may never have thought of a chicken's ears.] The teacher calls attention to the ears on the tame hen, or better, the children find them. Why is it well

that her ears are so small? Why do the ears need to be thus protected?

It is said that a hen's scent is good, as well as her hearing. How can we find out if this is so? Where is this hen's nose. (The children will find its nostrils, quite likely.) How are they protected?

Now look at this hen and tell me what you *like* about her looks. (Her feathers are pretty.) What is it that you admire about her feathers? What else do you think is pretty about the hen? (She wears a pretty red comb on top of her head.) How do you like the looks of the little chicks? (They are cunning.) How are they dressed? (In fluffy down.) With their round bodies and heads, and tiny wings and bills, and bright little eyes they make a beautiful sight.

Where did these little chicks come from? (From eggs.) How do you know? (Before the chickens are hatched, the mother hen must sit on the eggs three weeks, keeping them warm all the time, or they are kept warm in an incubator.) How does the hen get food and drink? (She leaves the nest just long enough to get food and water.) Would you know a setting hen were you to meet one? How? When the little chicks are ready to leave the shell who opens their shell door for them? (They do.) How? (Notice the little drill on the bill.) Do you see it on the bills of the older chickens? At what time of the year do these little chicks come into the world? (In

warm weather, usually, in spring or summer.) Why not in cold weather? How do they get a living when young? How many little chicks has the mother often to scratch for? Does she complain about her hard work? (No, she likes it.) How does she call her little chicks when she finds a nice worm? How does she talk with them as she walks out? And how do the little chicks answer her? (By a happy little "peep, peep.") But when one gets out of sight of its mother or gets into trouble? (Then it cries a loud, long, lonesome wail, until its mamma hears it and runs to it, or some person comes to help it. It is a good thing a chicken can let us know when it is in trouble.)

What kind of a sound does the mother make when she sees a hawk in the sky or a snake in the grass? What does this sound tell the little chickens to do? (To hide in the grass.) Does the mother hide, too? (No, she is ready to fight for her babies if there is need of it.) How can she fight? (With her bill, wings, and feet.) Did you ever see her fight an enemy? Tell about it. Teacher also relates instances.

How old are the little chickens when the feathers begin to grow? Where do you first notice these new feathers growing? How big are the little roosters when they begin to crow? How well do they crow? Tell how they look when trying to crow.

Review the life of the little chick from the time the

hen goes on to the nest to begin her setting, up to the time when the feathers begin to grow. Third eyelid. Warmth of body.

How else are eggs used besides for setting? Children tell of the many uses of eggs. How do we know that a hen has laid an egg? (She cackles.)

The Corn, or Maize

A mature stalk of corn, some fifteen feet tall, as it has just reached its full growth in the field, is one of the finest specimens of plant life that can be found. Such a plant is one of the chief ornaments in any botanical garden. Its powerful stalk, broad pennon-like leaves, towering tassels, and heavy ears loaded with grain would furnish an unparalleled symbol of the richness and strength of agriculture. And this marvel of growth and perfection has been produced in about four months of the summer season.

The maize is the characteristic cereal of the western world. Its history is bound up with that of America from times long before Columbus to the present, and it takes first rank now among the great cereals of the world.

Its native home was originally in Mexico or the warmer parts of America, but its cultivation now extends into Minnesota and through all the states of the Union. The full growth and ripening of the maize requires a warm, summer climate, so that it is not raised in northern Europe as in Germany and in

England. But its cultivation is extensive in southern Europe, in Africa, and in Asia.

The full-grown corn plant is interesting from the peculiar adaptation of its various parts to their uses. The main stalk consists of a series of nodes and internodes, very thick and heavy at the bottom, but tapering gradually toward the top where there is little strain. This stalk is hollow except at the joints, or is filled with a light pith which adds little to the strength or weight of the plant. This tubular structure gives great strength with least weight, and seems based on the same principle as the tubular column in iron construction of buildings. At the joints or nodes, however, the stalk is solid and hard so that the stalk is prevented from bending and collapsing as a long, hollow cane would easily do. The lower part of the stalk has thick, short internodes so as to give greater strength, for the great height of the plant produces a heavy strain upon the lower parts. The hard part of the outer stalk consists of long woody fibres closely packed and producing a strong rind. The pithy inner part of the stalk has only scattered threads of strong fibre.

The long, graceful leaves are fastened to the nodes. Each of these long leaves consists of two distinct parts, the sheath and the blade. The lower part, or sheath, rising from the joint, circles the stalk above and clasps it tightly, forming a complete tubular incasement the whole length of the internode.

From the top of the sheath the distinctly marked blade swings out from the stalk and droops gracefully downward. Long threads or fibres run parallel lengthwise of the leaf and give it strength and flexibility, the structure of the sheath and blade is such that the whole leaf swings somewhat freely, and in a strong wind makes the least pull or strain upon the main stalk. This free motion is due to the fact that the sheath is flexible at the top, and the edges of the blade are scalloped so as to allow an easy bending of the blade from side to side.

At the point of union of the sheath and blade is the rain guard, which prevents the rain from flowing into the pocket between the sheath and stalk, and carrying waste material to injure the plant. Instead of this the water rolls off and is carried to the roots of the plant where it will do best service. We shall notice later that the sheath and blade in other important ways contribute to the growth and protection of the whole plant.

It is easily observed that about halfway up the stalk the main ear grows in the axil of the leaf, or rather between the sheath and the stalk. In its earlier growth it is completely wrapped and covered by the sheath, but with growing size it makes room for itself and forces back the sheath, projects its silk into sight, and as it ripens bends down with its heavy weight and hangs outside the sheath.

An examination of the means of attaching the

base of the ear to the axil of the leaf will bring out the curious fact that the ear itself is the end of a jointed stalk similar to that of the whole corn stalk, and that the husks which wrap the ear are successive leaves on this short stalk very similar to those attached to the main stem. In fact, the outer husks, enveloping the ear, are seen to have short blades separated from the sheathlike husk by a rain guard. In their general structure, the ear and husks have the same form as the main stalk and leaves.

The growth of the ear and the ripening of the seeds of corn on the cob may be regarded as the centre of operations for the whole corn plant. All the parts may be looked upon as branches of a manufacturing establishment for storing the ear with well-ripened seeds. The broad leaves spread themselves in the sun and prepare the food for the growth of the plant and for storing the seeds with nutriment. The roots gather moisture and strength from the soil, and other parts convey this gathered food from the soil to the ear.

The corn plant provides for the development of its seeds in a curious way. The ear is a spike, covered thickly with pistillate blossoms, with long hairlike pistils whose ends hang as the "silk" from the tip of the ear. The staminate blossoms are in the tall tassel which as it tosses in the breeze shakes from its yellow cells the abundant pollen grains and scatters them widely by the aid of the wind. When

one of these pollen grains falls upon a silken hair, it causes the ovule of corn connected with this delicate thread to germinate and grow to a full seed. If one walks through a corn-field in September, he will find all the leaves and stalks, and even the ground, powdered with these pollen grains. There is then little danger but that all the silks will be well powdered with the fertilizing pollen, so that the ears will be richly stored. The pollen from one plant is blown and scattered upon the neighboring stalks, producing what is called cross-pollination, which is supposed to produce a better result than when the grains fall from the tassel upon the silks of the same plant. Not only is there an abundant supply of pollen in the tassels, but the silks remain fresh and green for several days, so that in case of rainy weather there is still time to fertilize the silks after the rains are over.

While the grains on the ear are growing and filling they are soft and tender, and are said to be in the milk. At this time they make good roasting ears. Sometimes the grub of the corn-worm hatches out in the end of the ear, and eats its way into the rich grains of corn, partly spoiling the fruit. The birds would doubtless enjoy the sweet, tender corn at this stage of its growth, but the ear is well protected by a thick cover of green husks, so that its outside enemies cannot easily get into it. Sometimes a kind of smut attacks the ear and produces a great puffy, black mass, completely spoiling the ear.

In many parts of the country the growing corn-fields are seriously damaged by the chinch-bug, which sometimes infests the growing corn in great numbers. They are little black insects which suck the juices from the leaves and stalk, and ruin the fields. The Agricultural Station at the University of Illinois and those of other western states have experimented in all sorts of ways for checking the ravages of the chinch-bug. Among other things, bugs infected with parasitic diseases have been sent out to the farmers to spread the disease among the insects in the fields. Circulars are also sent out from the State University describing the best methods of fighting the chinch-bug. It has been computed that the losses to farmers of the United States in a single year, from the damages of the chinch-bug, amount to twenty million dollars.

When the ear ripens in the fall, the grains become hard and are firmly attached to the cob, so that in gathering and husking it the grains do not shell off. If this were not true the corn would not be of much advantage to man. Most plants drop or scatter their seed when ripe, but the corn holds it tightly, and man is able to collect and store it for use. In this respect it is much like wheat and other grains.

The roots of the corn plant by which it is able to hold itself upright in spite of its great height are of curious interest. A close examination will show that there are several short nodes, crowded close together

near the surface of the ground, and that roots start out from these and firmly anchor the plant in the spongy soil. Besides these roots in and near the surface, one or two of the nodes above the surface often send down brace roots which not only root themselves in the ground (looking something like the stays of a ship's mast), but they are stiff and hard and even serve to brace the stem. Any one who will try to draw a large corn plant from the ground will find how firmly it is anchored, and how stout its roots are.

These roots are also indispensable to the plant in collecting food and moisture from the earth. In dry seasons they must penetrate deeper into the moist earth for the dampness that lies far below the surface. The frequent cultivation of the soil, by keeping a light cover of loose earth on the surface, prevents moisture from escaping from the soil.

The growth of the corn plant from the germination of the seed to the full ripening of the ear is one of the most instructive lessons in botany. It requires a rich soil and a warm, even sultry, summer heat to give the best growth. The grain of corn is well stored with the starchy food that gives the tiny plantlet its first growing nourishment and strength. The rootlet strikes into the earth and soon a little pointed blade points upward. This blade is tube-like and as it shoots upward encloses within itself the next leaf, and this in turn as it develops encloses a

third, and so on. The sheath of each leaf remains wrapped round the stalk, strengthening and supporting it so that the leaf in this way not only protects each on-coming tender leaf, but continues to strengthen greatly the main stalk throughout its later growth. Finally, when the stalk has reached its proper height a cluster of tassels rises and crowns the whole.

When the stalk has reached its full size, one or two large ears are seen in the axils of the leaves about its middle. A closer examination will reveal the fact that in descending the stalk from the large ear smaller ears will be found, one in the axil of each leaf, in many cases, almost to the ground. The farther down the stalk we go the more rudimentary is the ear, but in some cases three or four well-matured ears may be found. This has raised the question whether by selection and cultivation a species of corn could be produced which would yield two or three or more strong ears on each stalk, and at the experiment stations some tests have been made. Possibly the yield per acre could thus be largely increased.

The growth of the stalk reveals other very interesting processes in the plant. In order to produce a very rapid growth in a short season the corn does not confine its growth to the upper extremity as in trees and some other plants. But each internode has a region of growth so that if a corn plant has ten joints it is lengthening itself at ten places at the same time.

Just above each node is a green, fresh, growing part of the stalk where this growth takes place. It is interesting also to note that this is the part of the stalk which is best protected by the strong bottom part of the sheath. So rapid is the growth of the corn plant during the warm weather of July and August that plants sometimes attain a height of nearly twenty feet, and whole fields sometimes reach an average height of fifteen or sixteen feet.

In spite of the strong anchorage of the roots in the soil, heavy winds sometimes blow down the corn, especially when rains have softened the earth below. One would naturally think that a prostrate corn stalk would be in a hopeless condition, but it is often observed that in a day or two the fallen stalks have raised their heads and are making a tolerable effort to right themselves. The manner in which this is accomplished is one of the most curious adaptations in the life of the corn plant. It may be observed that on the under side of the prostrate stalk, and just above the node, the lower part of the sheath has thickened and solidified and has thus given an upward bend to the stalk at this point. When this is done at several nodes, the upper part of the stalk is found to stand erect and proceeds to develop in the normal manner.

The leaves of the corn also have an interesting way of adapting themselves to dry weather. The amount of moisture drawn from the earth by the

corn plant is very great, but in dry weather it is necessary to put up with a much smaller amount. As the leaves spread their broad surface to the sun, they send into the air a great amount of moisture drawn from the earth. In dry weather, in order to check the amount of this evaporation, the edges of the leaves roll up together and form a sort of tube, so that there is much less exposure of the green surface to the sun and air. When rainy weather comes again they once more spread their broad, flat surface to the sun and atmosphere. In this way the growing plant is able to adapt itself to great differences in weather and still carry on its work of growth and ripening its ears.

The effect of the cultivation of corn among the Indians, and later among the white races, has been to give a variety of kinds, such as field corn of several sorts and colors, sweet corn for gardens, and pop-corn. By cultivation, kinds have been produced which show a quick growth in the warm summers in lands as far north as Minnesota and Canada. Originally a tropical plant in Mexico and Central America, it has been made to mature its valuable harvest in the northern part of the United States.

The cultivation of corn among the Indians and pioneer white settlers was of great importance. Those nations in Mexico which were most successful in the regular cultivation of corn were the most advanced of the Indian races. The Indian races

which occupied the temperate parts of North America cultivated corn in a very rude way. The early settlers along the Atlantic coast found it of great value, much better adapted to their first clearings in the forest than wheat and other cereals. Maize is a much easier crop to raise, harvest, and convert into food than wheat and other grain. Its product to the acre is much greater. In pioneer days, therefore, the parched corn and meal, the succotash, hasty pudding, hominy, and pone cake enabled the people to extend their settlements and take possession of the country in a way that dependence upon wheat and rye and oats would not have allowed. When Robertson first visited the valley of East Tennessee, he raised the first summer a field of corn, and then returned to North Carolina to get his family and lead out a settlement. A similar dependence of the early settlers upon corn is shown in many ways.

The present uses of corn are so important and varied that their examination is of curious interest. Besides its uses in corn bread, as roasting ears, in canned product, in hasty pudding and other common dishes, it is the chief source of starch, glucose, whiskey, and alcohol.

In the fattening of farm stock for the market it is the chief cereal, and for this purpose the fodder or stover is becoming almost as important as the grain. The use of the green or partly ripened corn plants for filling silos, after it has been chopped up into

small bits, has become of great importance. A slight fermentation takes place and makes the silage a very rich food for dairy cows and other farm stock.

There are many other less important uses to which parts of the corn plant are put, as the stalk and husks for paper, mattresses, fibre, packing material, oil, and even fuel.

Not a little of the best ingenuity of the American people has been expended in inventing machines and processes for planting, cultivating, harvesting, and utilizing the product of the corn-fields. The result of this ingenuity would give us at least the following list: ploughs, corn-planters, cultivators, corn-cutters and huskers, corn-shellers, silage choppers, machines for milling corn, distilleries, canneries, to say nothing of the various devices of cookery for putting the corn plant into palatable forms. The treatment of corn in its various important phases is one of the best illustrations of the manifold applications of science to practical affairs.

The corn plant botanically considered is an important member of the grass family. It has a number of striking points of resemblance to the cereals, as wheat, oats, rye, and barley. The jointed hollow stem, the leaf and sheath, the terminal flower, the roots and general structure of the plant, the annual growth and the close retention of the seed instead of scattering to the wind, are identical in corn and the

other cereals. There is also a strong similarity of the food store in all these cereals.

The corn differs from all the other cereals in its great size and in the fact that it separates widely its staminate and pistillate blossoms, providing thus for a cross-pollination much greater than in the others.

But this whole group of cereals has a strong resemblance to the field and wild grasses. The chief point of contrast is that the wild grasses provide some mode of scattering their seed and thus securing a new growth from season to season. Their seeds are also smaller and are more easily carried by the winds.

It looks as if the cultivated cereals had somehow lost this power of providing for their offspring and had transferred it to man. In fact, man finds sufficient value in the seeds to provide for their preservation, sowing, and culture. It is even claimed that the cereals have gradually developed their present state of perfection as man has developed, and that their progress has largely conditioned his.

Method in treating the Corn Plant

The corn plant may be studied by the children at different times in the grades. A few of the chief opportunities for this study may be outlined as follows: —

1. The planting and germination of the corn in boxes in the window. Done probably in the second or third grade in early spring.

2. The planting and cultivation of the corn in the school or home garden. Watching its growth and changes through the seasons, including roasting ears of sweet corn and final ripening in the fall.

3. The close examination of the full-grown corn in September in the school garden. Large, full stalks are also brought into the schoolroom for study. A visit to the corn-field in September to note the conditions of growth, pollination, etc. This is the chief period of study of the corn in fourth or fifth grade.

4. Collection of other cereal plants and somewhat close comparison with the corn of wheat, rye, barley, oats, and rice. This can best be done perhaps in late spring just before the close of school in June, in fifth or sixth grade.

5. Collection of the full-sized corn plants, of grasses, as timothy, blue grass, and other wild grasses, for comparison with the corn and other cereals. This can be done both in June and in September in connection with the studies previously mentioned. It is well also to compare the seeds of the grasses with those of the cereals.

6. The uses of corn in connection with feeding of cattle, horses, and hogs, chickens and other fowls, on the farm may be noticed in connection with the previous topics. The silo on a farm is an interesting study. Other farm studies in geography and science also treat these topics.

7. The visit to an agricultural implement store to

notice definitely the kinds of machinery used in connection with corn production and use will be worth the trouble. Still better is it to observe the uses of these machines in the fields and barns.

8. The preparation and uses of corn and meal in the kitchen, test for starch, food value of corn, making corn bread, hominy, succotash, mush, roasting ears, etc.; these topics can be worked out in connection with the various lessons in cooking in sixth and seventh grades.

9. The importance of corn in the agriculture and commerce of the United States is clearly brought out in the geography lessons of the fifth and sixth grades.

10. The story of Mondamin, the corn plant, and the legends of the Indians regarding it are given in a classic form in "Hiawatha," and this poem is now often read by the children in the fifth grade, and used in the story form in the second grade. Whittier's "Corn-Song," and "The Huskers," and other illustrations of the topic in literature are familiar.

11. The Pioneer history stories have a great many illustrations of the use of corn among the Indians and early settlers. Corn was, in fact, an important part of the Indian and pioneer environment.

12. In the cultivation of corn in the garden and in the cooking experiments in the kitchen the manual skill of the pupils in using tools, working in the soil, and in the more exact following of recipes is quite as valuable as the work of the shop.

That children in the natural course of their schooling run across the various aspects and relations of corn to the different studies, is evident. The connections between different branches of knowledge are so easy and natural that they are worked out incidentally without waste of time. It is interesting to observe that a commonplace, but really important, topic like this ramifies more or less into all studies.

The Skin

"Science Lesson for Fourth Grade." By Fred L. Charles.

We are now to study something that stands between us and the outside world; something that is of very great importance to our comfort and our welfare. What do we call the covering of the body? The skin. Evidently it is of what service? It protects the tender portions beneath; gives smooth outline and surface to the body. Is it of uniform thickness? Where thickest? On the palms and soles. What else protects certain parts of the body? The hair; the nails.

Name all the characteristics you can of the skin. It is soft, smooth, "flesh-colored," elastic — always fits the body tightly, although constantly subject to stretching and to pressure; can be grown again when cut or injured; is sensitive to touch and to heat and cold.

Did you ever have on your hands — due to hard

work or to a burn — a blister filled with a watery liquid, making the skin puff out like a little bag? Did this puffed-out skin finally come off? Was it sensitive? If you were careful in removing it, did blood flow? Was there a permanent scar? What was the nature of the skin beneath the blister? Its color? Was it sensitive? Did it contain blood? As the blister healed, where did the new skin come from? There are really two skins, the outer, scarf skin, cuticle, or epidermis; and the inner, true skin, or dermis. The blister was between the two. The outer skin, as you saw, has no blood and no nerves,— you can run a pin through it without pain, — but the nerves of the inner skin can feel through the epidermis. The thicker epidermis of the palms and soles affords the greater protection needed at those places. Where the skin turns in to line a passage such as the nostril or the mouth, it becomes "mucous membrane."

Does the scarf skin grow? How do you know? It is constantly wearing off on the surface, as seen when rubbing with a coarse towel after a hot bath. Necessity of bathing to remove these dead scales. Dandruff is the dead outer skin of the scalp. How must the cuticle be replaced? By the growth of the deeper layers. The coloring matter of the skin (blond, brunette, black in negro, copper in Indian, etc.) is located in the deeper layers of the outer skin. (Blisters are sometimes formed between two layers

of the epidermis instead of between the dermis and the epidermis.)

The inner, true skin, or dermis, is richly supplied with muscle fibres, blood-vessels, and nerves. There are also little tubes which lead up through the cuticle and open on the surface. On your palm you see several coarse lines, but all over its surface you find fine ridges; all along the ridges are the openings (pores) from these tubes. If you know how to use a magnifying-glass, you can see the pores distinctly. Do you know what comes through these pores? Perspiration — sweat. Try this experiment: Place your hand inside a cold glass fruit jar; after a few moments, what do you notice? What happened? Sweat is being given off all the time, — more than a pint daily, — usually drying as fast as it reaches the surface. Under what circumstances is it given off most freely? In warm weather; when dressed too warmly; after exercise; after drinking freely; after taking certain medicines. The sweat pores are found all over the body; from 400 to 2500 per square inch; a total of nearly 3,000,000; most numerous on the palms.

Of what use are the sweat glands? When the body is overheated, the evaporating perspiration carries away some of the body's heat, helping to keep its temperature nearly uniform, or constant; fanning brings fresh air to take up more moisture from the body and thus carry away more heat. To sit, when heated, in a draught of air may result in closing the

pores, producing a cold. What other service does the perspiration perform? The sweat glands take from the blood a great quantity of worn-out particles and waste matter, carrying it to the surface. This service makes the skin a very important workman of the body. Knowing these facts, we can better understand the necessity of bathing to keep the pores open, to remove foreign matter (dirt) and also the refuse (sewage) left by the perspiration when it evaporates. Why is it best to change the underclothing frequently? How does the skin suffer from our overeating? It has too much work to do in removing waste matter.

The skin has also oil glands, which open along the hairs, oiling them and keeping the skin soft. Stoppage of these openings produces pimples or even boils. Here is an added necessity for cleanliness.

Frogs and earthworms breathe largely through their skin; they suffer and die if it becomes dry. We, too, may breathe, though but very slightly, through the skin, which coöperates with the lungs in taking in air (oxygen) and giving off waste. The skin may also absorb substances rubbed upon it; for example, liniment. Necessity for keeping the surface clean and healthy; frequent bathing and change of clothing to prevent the absorption of waste or poisonous matters.

What change do you notice in the skin when you enter a very warm room, or when you exercise vigor-

ously? It becomes "flushed"—filled with blood. Of what advantage is this? It regulates the body's temperature. We saw how heat is carried away by perspiration; it is also lost directly from the blood as the warm current passes through the flushed skin. What change when you go into the cold? The skin becomes white; heat is then retained by the withdrawal of blood from the surface (by constriction of the blood-vessels in the skin). Exercise speeds the circulation; shivering is an involuntary exercise—what an interesting provision!

Functions of the skin, summarized: (1) protection; (2) sensation; (3) excretion — purifying blood; (4) heat regulation; (5) absorption of oxygen and ointments.

This study of the skin may well be followed by a discussion of the growth and care of the hair and the nails, and of the hygiene of bathing.

Experimental Study of Water in the Plant

"Eighth Grade." By Fred L. Charles.

(This study, as all other experimentation in the grades, should be introduced as a means for solving a problem which has arisen. If possible, it should be the pupil's means of solution, suggested by him. It is assumed that the work here outlined shall be given such a setting. Suitable occasion for its introduction

may be found in connection with the topic of autumn coloration, the care of house plants, the conservation of soil moisture in the garden or field, or in a study of developing seedlings. The work may be adapted to any grade above the fourth.)

We are all familiar with the care given to house plants. They insist that their relations to soil, light, temperature, and moisture be properly adjusted. Their most frequent demand upon us is for water. "Be sure to water the plants!" is the last injunction of the thrifty housekeeper when departing from home. Outdoor plants need the same conditions and, though more hardy, they thrive or suffer according to the frequency and amount of rainfall. We will investigate the ways and means and uses of this water supply as they are evidenced by the structure and (especially) the activities of the plant.

A wilted plant revives when watered. Evidently the water can get from the soil into the body of the plant only through the root system. Water can be absorbed only by the young and tender portions of the root. What is the mechanism? Looking at a young plantlet of radish or corn (grown in moist chamber on damp blotting-paper or cotton), we discover numberless fuzzy outgrowths (root hairs) on the roots of the seedling. The root hairs increase enormously the absorbing surface; wrapping closely about the soil particles they lay claim to the enveloping

moisture and to the mineral (food) substances dissolved therein. The root hairs are easily seen with the naked eye, or, better, by the aid of any form of magnifying glass or microscope. (Understand that root hairs are not so abundant in soil-grown roots.)

How active is the root in taking up moisture from the soil? Let us answer this question by experiment. From a potted begonia plant cut the stem with a sharp knife, about two inches above the soil. Keep the cut surface moist. By means of a short piece of rubber tubing attach to the stem a piece of glass tubing, supported by a rod. Water the plant as usual. The glass tubing shows the rise of "sap"; mark the height of the liquid at intervals. The upward force of this liquid, rising from the roots against gravity, is known as root pressure. It may be demonstrated in the garden, using a dahlia or tomato plant or a young sapling. Thus it is seen that the root system of a plant constitutes a channel for the escape of water from the soil.

What is the explanation of this root pressure? What agencies are at work? We can partially answer this query, although we must remember that where a living thing is at work, there is a much more complicated situation than exists in lifeless apparatus. Close the tube end of a "thistle tube" and pour salt in until the bowl is nearly filled. Over the mouth stretch and tie firmly a piece of parchment or bladder skin. Place the thistle tube, bowl down, in a tumbler

of water. Very soon we notice that the liquid is rising in the tube. This intermingling of two liquids of different density, through a membrane, is called osmosis. After some time it may be determined that the water in the tumbler is somewhat salty. The "thinner" fluid had less difficulty in getting through the membrane, hence the diffusion current was much greater (at first) toward the dense solution. This throws much light upon the question of how the soil moisture enters the root hairs. The living substance (protoplasm) of the cells is the membrane, and water enters, while very little sap goes out. In different plants growing side by side, fed by the same soil moisture, we find that the roots select out different percentages of various mineral foods, evidently in accordance with their needs. To illustrate, the hard stalks of stubble in the grain field have been furnished more quartz (silica) than have the clover stems growing alongside.

Let us illustrate osmosis in a different way. With sealing-wax cement a glass tube to the small end of an egg, and then pierce the shell and membrane by means of a long needle or wire run through the tube. Without injury to the lining membrane, break away the shell from the large end of the egg, over a surface about as large as a dime. Support the large end of the egg in a wide-mouthed bottle of water, and await results. A liquid appears in the tube and rises to a considerable height. Evidently osmosis is going

on, through the membrane, between the egg contents and the water; the more rapid movement is into the egg. After a while you may discover a change in the water in the bottle. In some similar way the soil moisture enters the root system, and is raised through the stem (in considerable measure) by osmosis from cell to cell.

Slices of raw beet put into a strong solution of salt water become limp; why? Water moves from the beet into the denser salt solution; the cells "wilt." Placing the wilted beet slices into fresh water revives them; the greater current now is from the fresh water into the beet, which becomes turgid again. The cell is much like a cloth bag and must be filled before it can stand erect. So leaves wilt when deprived of needed water.

Does the root act alone in pumping water from the ground? Does any other organ of the plant coöperate? Let the leaf answer for itself. Place a leafy stem of wild black cherry or a detached leaf of a plantain weed in red ink (eosin); the colored fluid ascends rapidly — at different rates in different plants — and by channels easily demonstrated in some forms, as in the plantain. In preparing material to illustrate the ascent of sap, cut the stem under water. By using different plants you will discover interesting differences in rapidity of ascent and in the character of the passageways. Try the stem and blossom of the mandrake.

What becomes of the moisture that reaches the leaf through the stem? How shall we solve this question? Pass the petiole of a leaf through a cardboard by means of a hole just large enough to admit it; immerse the freshly cut end of the petiole in a tumbler of water, and invert over the leaf (and cardboard) another tumbler. What happens? The leaf does not retain all of the moisture it receives, but gives off a great amount into the air. An acre of grass gives off several tons of water per day; sap must rise to replace the water lost; hence there must be an enormous upward flow of water through the plant every day.

How does the water escape from the leaf? From the lower surface of a leaf of lily-of-the-valley, or of wandering Jew, obtain a small strip of the thin, transparent epidermis. Mount it in water under a microscope. The little structures resembling apple seeds distributed among the epidermal cells are the "stomates," or breathing pores, through which water vapor escapes from the leaf and through which air enters. You will find it interesting to read about stomates in any good general botany. Do you discover the two guard cells, or lips, which guard each stomate and regulate the amount of water given off?

This activity of the plant in thus passing an immense amount of water daily through its body must signify something of great importance. The object is, in large part, to keep the plant turgid and

erect; but the main purpose is to obtain the food which is in solution in the water. Large quantities of the weak solution must be disposed of in order to obtain only a small amount of food.

Helpful suggestions will be found in the following books: Bailey's "Foundations of Botany"; Macdougal's "Experimental Plant Physiology"; Kerner and Oliver's "Natural History of Plants"; Coulter's "Plant Studies."

The considerations herein presented open up many related topics, such as the relation of forests to rainfall, the flow of sap, food storage in plants, etc.

As a last injunction, let it be the constant care of the teacher that the problems, the means of solution, and the mechanical work be so far as possible in the hands of the pupils.

CHAPTER IX

THE COURSE OF STUDY

The Course of Study in Elementary Science laid out in the following chapter may be regarded as the backbone of the present book. In this course of study all the chapters of the book should focus. They should all contribute directly to the realization of the plan there worked out.

We believe that a point has been reached where a definitely arranged course of study for the grades is demanded, and that the controlling points of view from which such a course can be rationally made out may be plainly demonstrated.

Assuming this conclusion to be correct, we may first ask ourselves the advantages which may flow from such a series of topics for a course of study as can now be made.

First. Such a course picks out a few centres where the efforts of teachers and pupils may be concentrated. In view of the countless multitude and variety of nature-study topics, even a moderate degree of success in selecting would be a great unburdening. A course of study which will give us the typical and essential in the vast field will be a priceless economy.

Second. The individual teachers should be relieved of the burden of selecting and arranging such a course. To leave this heavy problem in the hands of young and inexperienced teachers is worse than folly. There are, in fact, very few old and seasoned superintendents who would not hesitate to lay out a definite course of study in elementary science. Yet their experience and qualifications for such a task must be twenty times that of the average grade teacher. Evidently such a course should be made out for the whole elementary school, not in eight unconnected fragments by eight people of different ideas. A wise superintendent will get together the best of his teachers and experts in nature study, and by mutual coöperation work out this problem. But we greatly need a much better course of study than has yet been worked out in this way. That the average grade teacher is wholly unqualified for this great task and should not be burdened with it ought to be frankly admitted.

Third. When a fairly good course of study (properly arranged through the grades with its great series of well-established centres) has been marked out, the rich and appropriate knowledge may be collected which is able to make these topics fruitful and profitable to children. This collecting of choice knowledge is a nice problem, requiring no small degree of scientific skill and pedagogical experience. To enrich these central topics with concrete knowledge ap-

propriate to children is undoubtedly the work of specialists.

To expect the average teacher to hunt up and bring together this fine assortment of knowledge and material is pure hallucination. An enthusiastic teacher of large experience, by overwork, or by neglecting other important things may accomplish this task for a single grade, but it is wholly unreasonable to expect it or to require it of anybody.

It is the business of specialists to select and organize this choice material of instruction and to put it into the handiest form for the teacher's immediate use. To master, assimilate, and skilfully use this gathered material in classes is the special task of the grade teacher, and this requires a full measure of labor, originality, and skill.

Already a goodly number of important topics have been worked over in this way by specialists, and the suitable material brought into convenient form for the grade teacher. Enough, therefore, has been accomplished to demonstrate the feasibility of this plan. The poor results that have come from nature-study lessons have been due largely to the double burden which has been laid upon grade teachers, that of first collecting and working up the knowledge of these topics without proper helps, and that of the legitimate work of skilful ordering and instruction. We have been expecting grade teachers to make bricks without straw. The doctrine of division

of labor applies with redoubled force to this branch of instruction in its present condition.

Fourth. On the basis of the two points just named, it is possible for the teacher to concentrate her labors upon her peculiar task ; namely, the mastery of this well-assorted material for the purposes of skilful instruction, in short, what may be called knowledge and method. The principles of science instruction have been well worked out in full illustrations of the treatment of important topics. The study of these illustrations involves no slavish imitation of others' methods and processes, but rather a rational and even critical study of what the best teachers have done. This offers to every teacher a profitable field for thoughtful study, rational imitation of good models, and the development of original power and resource.

Fifth. A well-arranged series of topics extending through the grades makes possible an orderly development of certain coherent lines of thought from year to year. Most people have felt the inherent weakness of our elementary science courses when judged from this fundamental point of view. Latin and arithmetic, for example, are supposed to possess this underlying coherency of thought, so that each later year's work is reënforced and strengthened by the earlier, and is, in fact, dependent upon it. The broad sweep and variety of nature studies have seemed to obliterate any connected plan and have left us in the confusion of a multitude of details.

There are, however, a few important centres of nature-study work whose topics recur from year to year in continuous development. Such, for example, are the topics connected with health and physiology, plant life, sanitation, cooking, gardening and agriculture, applied physics, insect life, etc. In spite of the apparent miscellaneous character of its topics the great body of science lessons consists of several strong series of connected topics running through the grades. No study can be strongly educative that does not thus build steadily upon previous foundations. There is scarcely a lesson in the middle and later grades that does not reach back into two or more, often many, of the previous lessons. Good teaching will always recall these previous lessons and make use of them in building up an enlarged body of connected knowledge.

A well-arranged course of study enables the teacher in any of the later grades to look back and to find out the previous acquisitions of the children, to review these lessons and bring them into proper relation to the later studies. This review and focussing of all earlier lessons upon later ones is the essence of good teaching. Without a course of study or with a poor one this important result is defeated.

Sixth. A well-selected course of study in elementary science makes it possible for the teacher in any grade to concentrate her studies upon a few important topics suited to that grade, so as to become well

equipped for teaching them. The great majority of elementary teachers have not been trained for teaching nature study, and they must pick up the essentials by the way. If the sources of knowledge are made easily available, energetic teachers will soon acquire an abundant material of experience and information. But it must be of the right sort and easily at hand.

The following course of study contains probably a larger list of topics than can be worked out fully in any one school, and will have to be modified to fit the needs of any particular locality. Every school will have to change such a plan to meet its own needs.

Different neighborhoods (city and country or village life), and physical and climatic conditions in different parts of the United States, are so widely divergent that a definite course of study must be changed and adapted to local surroundings and needs.

For these reasons any one course of study should be suggestive of broad and common lines of study, and yet as definite as possible in specific, typical topics.

OUTLINE OF NATURE STUDY

Fall Term. — First Grade[1]

1. *Birds*. (*a*) Note the coming of the fall and winter birds after acquainting the children with them through the use of mounted specimens or colored pictures. Good

[1] These topics need not be taken up in the order given here. The changes in nature will suggest the order.

colored pictures of birds can be obtained from the Perry Pictures Co., Malden, Mass., or from A. W. Mumford, 378 Wabash Ave., Chicago, Ill. Do not use too many pictures. See that the outdoor observations are the main thing. Children easily deceive themselves and describe for outdoor observations what they remember of the pictures. In northern Illinois the children will look for the nuthatches, the brown creepers, the kinglets, the juncos, and the chickadees.

(*b*) Report every day that the robin and blackbird are seen. They will probably be last seen in October.

(*c*) What other birds are here?

2. *Flowers.* (*a*) Learn the names of the common fall flowers and associate with each a few striking characteristics. Press a good specimen of each variety and mount all on a large sheet of cardboard, writing or printing by each its name and date. Where is each found and in company with what other flowers? (*List* of half-dozen.)

(*b*) Study cinquefoil, evening primrose, and horsemint, or other common flowers.

(*c*) Early in the term study the blossoms and plants of nasturtium and Lima bean. Save seeds of each for spring planting.

3. *Trees.* (*a*) Learn to recognize trees by their fruits and by their leaves. The identification is associated with gathering the beautiful autumn leaves and nuts.

(*b*) Press some of the leaves and mount on a large sheet of cardboard, placing by the side of each leaf its fruit in all cases where the latter can be obtained.

(*c*) Notice the galls on the oak, cottonwood, willow, and linden trees. Open to find what each contains.

4. *Vegetables.* Recognize and name the fall vegetables. Model in clay.

5. Detailed study of the apple and the peach. Plant apple seeds and peach pits.

6. *Domestic animals.* Life histories of the cat and the dog.

7. *Wild animals.* Home life of the squirrel.

8. *Insects.* Early in September gather a few grasshoppers, locusts, and crickets. Place each kind in a glass jar in which there are three or four inches of soil. Feed with grass and bits of apple, beet, and carrot. Try other articles of food. See that they are fed each day. Quite likely some of them will lay eggs in the ground.

Find how the cricket's chirp is made.

9. *Weather charts.* Each month rule off on a large sheet of cardboard as many one and one-half inch squares as there are days in a month. Make seven in a row, one for each day in the week. On a bright day place a yellow circle in the square in which the day's weather is to be recorded. On a cloudy day use a gray circle. A half circle of yellow or gray indicates the kind of weather for a half day. Special days, *e.g.* Washington's birthday, may be marked by some emblem of significance of the day placed upon the circle.

Make summaries at the end of each week of the number of bright days and the number of dark days during that week. At the end of a month find the number of bright days and the number of dark days in the month. At the end of the year compare the calendars to find the pleasantest month and the darkest month.

HELPS

1. *Migration of birds.*

Everyday Birds (Bradford Torrey).
How to Attract Birds (Neltje Blanchan).
First Book of Birds (Olive Thorne Miller).

The Foot-path Way (Bradford Torrey).
Bird Life (Frank Chapman).

2. *Helps in the naming and study of flowers.*
Nature's Garden (Neltje Blanchan).
A Guide to the Wild Flowers (Alice Lounsberry).
Field Book of American Wild Flowers (F. Schuyler Mathews).
Familiar Flowers of Field and Garden (F. Schuyler Mathews).
According to Seasons (Frances Theodora Parsons).
Wild Flowers of America (Goodale).
For the study of the nasturtium, see —
Lessons in Nature Study (McMurry).
Flowers and their Friends (Margaret Morley).
A Few Familiar Flowers (Margaret Morley).
A good botany will help in the study of both the nasturtium and the bean.

3. *Helps in the study of the trees.*
Our Native Trees and How to Identify Them (Harriet S. Keeler).
Familiar Trees and their Leaves (F. Schuyler Mathews).
Trees of the Northern United States (Austin C. Apgar).
See chapter on "Galls" in Among the Moths and Butterflies (Julia P. Ballard).

4. *Vegetables.*
Lessons in Nature Study (McMurry).

5. *The apple.*
For appreciation of the apple, see —
The Apple (John Burroughs).
Nature Study and Life (Hodge).

6. *The peach.* See —
Lessons in Nature Study (McMurry).

7. *The cat.*
   - The Cat (R. S. Hinderkoper).
   - Our Home Pets (Olive Thorne Miller).
   - Schmeil, Introduction to Zoölogy.

8. *The dog.*
   - Animal Memoirs, Part I (Dr. Lockwood).
   - Our Home Pets (Olive Thorne Miller).
   - Special Method in Science (McMurry).
   - Domesticated Animals (N. S. Shaler).
   - The Play of Animals (Karl Groos).
   - Training of a Hunting Dog, *Country Life in America*, November, 1903.
   - Beautiful Joe.
   - Science Reader, Book I.
   - Lange's Handbook of Nature Study.
   - Cats and Dogs (James Johonnot).
   - Lives of the Hunted (Ernest Thompson Seton).

9. *The squirrel.*
   - Squirrels and Other Fur Bearers (John Burroughs).
   - Lobo, Rag, and Vixen (Ernest Thompson Seton).
   - Lessons in Science (McMurry).
   - Wild Neighbors (Ernest Ingersoll).
   - Winter Sunshine (John Burroughs).
   - Country Cousins (Ernest Ingersoll).
   - Life of Animals (Mammals) (Brehm).

10. *For study of grasshoppers, locusts, and crickets,* see —
    - Life Histories of American Insects (Clarence Moores Weed).
    - Little Folks in Feathers and Fur (Olive Thorne Miller).
    - Zoölogy, 2 vols. (Colton).
    - Insect Life (John Henry Comstock).
    - Needham's Elementary Lessons in Zoölogy.

Winter Term. — First Grade

1. *Domestic animals.* Study of the cow, the horse, and the tame rabbit.

2. *Wild animals.* Life of the gray rabbit, comparing it with that of the tame rabbit.

3. *Clothing of the children,* connected with the use, and adaptability to use, of the coats of animals previously studied. Kinds and uses of clothing. Dangers of scanty or wet clothing.

4. *Goldfish.* Uses of fins and tail in moving about. How they eat. How they breathe.

5. *Frost.* As seen in its effects, *e.g.* painting of the window panes, breaking of pitchers and water-pipes.

6. *Birds.* (*a*) Have a care for the winter birds. Attract them to the school building by providing meals in a certain spot every day. Hang suet in trees near by.

(*b*) The latter part of the term look for the return of the early spring birds. In northern Illinois they are the robin, bluebird, blackbird, red-winged blackbird, meadow-lark, and song-sparrow.

7. Plan the school garden and get seeds of Lima bean and nasturtium ready for planting in boxes in the house early in the spring term.

8. *Trees.* (*a*) Watch for pussy-willows and silver maple blossoms. (*b*) Early in the term notice the large buds of some tree, *e.g.* the buckeye or hickory. See if any changes appear in these buds later in the term.

HELPS

1. (*a*) The cow.

Cats and Dogs (James Johonnot).

Davenport, Leaflets on Agriculture in the School News.

(*b*) The horse.
The Horse (Flower).
Modern Science Series.
Black Beauty (Sewell).
Cats and Dogs (James Johonnot).

2. *Gray rabbit.*
Wild Neighbors (Ernest Ingersoll).
Animal Memoirs, Part I (Dr. Lockwood).
Squirrels and Other Fur Bearers (John Burroughs).
Lobo, Rag, and Vixen (Ernest Thompson Seton).
Science Reader, Book 2 (Vincent T. Murché).
Four-footed Americans (Mabel Osgood Wright).

3. *Clothing.*
Science Reader, Book 5 (Vincent T. Murché).
Zoölogy, 2 vols. (Colton).

4. *Goldfish.*

5. *How to attract the birds.*
Everyday Birds (Bradford Torrey).
First Book of Birds (Olive Thorne Miller).
How to Attract the Birds (Neltje Blanchan).
Nature Study and Life (Hodge).
The Clerk of the Woods (Bradford Torrey).
Birds in the Bush (Bradford Torrey).
The Foot-path Way (Bradford Torrey).
Bird-dom (Leander Keyser).
In Bird Land (Leander Keyser).
Home Studies in Nature (Mary Treat).
The Clerk of the Woods (Bradford Torrey).
Bird Homes (Dugmore). Doubleday, Page & Co.

6. *School gardens.*
How to Make School Gardens (Hemenway).
Kindergarten Review, 10 : 22.
Garden Making (Bailey).

7. In addition to the books already mentioned on trees, see —
   Little Wanderers (Margaret Morley), for study of the pussy-willow, and
   Talks Afield (L. H. Bailey).
   Ten New England Blossoms (Clarence Moores Weed).
   Seed Travellers (Clarence Moores Weed).
   Study of Trees in Winter (Hutchinson).
   Flower and Fruit (Jane H. Newell).
   Lessons with Plants (L. H. Bailey).
   Our Native Shrubs (Keeler).

Spring Term. — First Grade

1. *Birds.* (*a*) Watch for the newcomers. There will be many of them. Learn their names before they come, if possible, as suggested before. Notice what the birds are doing, and make daily reports if there is anything of interest to tell. Hold closely to actual observations.

(*b*) Study in detail the robin and the red-headed woodpecker.

2. *Flowers.* (*a*) Watch for the early spring flowers. As they are brought in, press one of each and mount on a large cardboard, giving its name and the date when found.

(*b*) Study in detail the violet and (*c*) the spring beauty.

3. *Trees.* (*a*) Watch the development of the buds studied last term. Watch, also, the development of the buds of the apple and peach to complete the study of these fruits begun in the fall.

(*b*) Notice what trees are first in leaf and identify trees by their green leaves.

(*c*) Gather seeds of silver maple, elms, willows, cottonwood, and poplars, — any or all of these, — and complete the tree charts begun in the fall.

(*d*) Plant seeds of each in the school garden and watch their growth.

(*e*) Watch and care for the seedling apple and peach trees.

4. *Germination of seeds.* Early in the term plant in boxes in the schoolhouse seeds of Lima bean and nasturtium. Watch and describe developments. This will complete the study of these plants which was begun in the fall.

5. Plant in the school garden Lima beans and nasturtiums for fall study of the entering classes. Watch their growth and give them good care, watering, if necessary, and keeping free from weeds.

Raise enough beans so that the children may store up a quantity of the ripe seeds to send out at Thanksgiving time to those who are in need. The nasturtium blossoms may be sent to sick rooms or to children's hospitals, and may be used also to decorate the schoolrooms.

HELPS IN SPRING STUDY

1. (*a*) *How to identify the birds.*

Bird Neighbors (Neltje Blanchan).
Birds that Hunt and are Hunted (Blanchan).
Bird-dom (Leander Keyser).
Bird Life (Frank M. Chapman).
Handbook of Birds (Chapman).
The Common Land Birds of New England (Wilcox).
Wild Birds in City Park (Walter).

(*b*) *Robin.*

Animal Memoirs, Part II (Dr. Lockwood).
Birds and Poets (John Burroughs).
Upon the Tree-tops (Olive Thorne Miller).
Birds through an Opera Glass (Florence Merriam).
Lessons in Science (McMurry).

(*c*) *Red-headed woodpecker.*

The Woodpeckers (Eckstorm).

Animal Memoirs, Part II (Dr. Lockwood).

Nestlings of Forest and Marsh (Irene Grovenor Wheelock).

Lessons in Science (McMurry).

2. (*a*) *How to identify the flowers* — see books suggested for fall flower study.

(*b*) *The violet*, see —

Lessons in Nature Study (McMurry).

Flowers, Fruits, and Leaves (Sir John Lubbock).

Familiar Flowers of Field and Garden (F. Schuyler Mathews).

Ten New England Blossoms (Clarence Moores Weed).

Flower and Fruit (Jane H. Newell).

(*c*) *The spring beauty*, see —

Lessons in Nature Study (McMurry).

Ten New England Blossoms (Clarence Moores Weed).

How to Study Plants (Alphonse Wood).

Flower and Fruit (Jane H. Newell).

3. (*a*) *For study of buds*, see —

Lessons with Plants (L. H. Bailey).

Bailey's Botany.

Outlines of Lessons in Botany (Jane H. Newell).

Lessons in Nature Study (McMurry).

The Clerk of the Woods (Bradford Torrey).

(*b* and *c*) See books on study of trees suggested for fall study.

4. *For germination of seeds*, see —

Outlines of Lessons in Botany (Jane H. Newell).

Concerning a Few Common Plants (Goodale).

Atkinson's Botany.

Seed Babies (Margaret Morley).

Lessons with Plants (L. H. Bailey).
From Seed to Leaf (Jane H. Newell).
Lessons in Botany (Gray).

Fall Term. — Second Grade

1. (*a*) Review and continue the study of birds begun a year ago, learning the names and habits of additional birds. (*List.*)

(*b*) The common crow.

2. (*a*) Review the names and characteristics of the fall flowers learned a year ago. Add to the list many others.

(*b*) Study the pumpkin flower and fruit.

(*c*) Study the melon by comparison with the pumpkin.

(*d*) Study the sweet pea by comparison with the Lima bean.

(*e*) By comparison with the pea and bean study the red, white, and sweet clovers.

(*f*) Study in detail the wild black mustard. Later compare the hedge mustard and cresses with it.

(*g*) Study the sunflower as a type of the composites so common at this time of year.

(*h*) Compare other composite flowers, as the asters and daisy fleabane with it.

(*i*) Study in detail the morning-glory.

(*j*) Save seeds of pumpkin, morning-glory, sweet pea, and sunflower for spring planting.

3. *Trees.* (*a*) Review the names of the trees as the autumn leaves are gathered and learn the names of other trees.

(*b*) When the leaves are off the trees learn to recognize the different trees by their buds, by their outline, and by their bark. Let this study include the cherry and pear.

(*c*) Gather acorns of the different kinds of oak growing in

the vicinity and plant in the school garden where they will not be disturbed in the spring. Mark plainly the portion of ground occupied by each variety. Make a plat of the tree bed, also, for reference in the spring.

(*d*) Winter study of the Austrian pine.

(*e*) Other evergreen trees by comparison with the pine. Study just before Christmas.

(*f*) Continue to care for apple and plum seedlings.

4. *Fruits.* Detailed study of the grape. Make cuttings of the vine and plant in the tree garden. Plant seeds also.

5. *Butterflies.* (*a*) Detailed study of the "cabbage-worm" and milkweed caterpillar early in the term. Find eggs of the butterflies, if possible, and watch their development through the larva and chrysalid state. If the eggs cannot be procured, the caterpillars may be found. Collect and feed. Study the butterflies.

(*b*) Collect other caterpillars and feed. Notice how they feed and how they make their cradles or change into chrysalids. Supply dirt, leaves and twigs.

(*c*) Collect cocoons and keep through the winter in the schoolroom.

6. Dissemination of seeds. Notice two different ways of getting out into the world: (*a*) by flying, using wings, or a parachute, (*b*) by stealing rides on clothing or on the coats of animals.

7. *Bulbs.* Plant bulbs of crocus and tulips out of doors. By the first of October put Chinese lily bulbs into glass dishes of water and plant the paper white narcissus in pots for fall blossoms. Prepare proper soil. At intervals of two weeks or more plant a new supply of each.

8. Make calendars in book form in which records of the dark and sunny days are kept in colored crayons. The directions of the cold winds, the warmer winds, and the winds

that bring the snow are indicated by arrows pointing in the direction from which the wind comes.

9. Winter study of other evergreen trees.

10. Make in water-colors a picture of the landscape as it appears at the beginning of each month.

HELPS FOR FALL TERM

1. (*a*) See books suggested for the bird study of the previous year.

   (*b*) The crow.

   Some Common Birds in their Relation to Agriculture.
   Hawks and Owls from the Standpoint of a Farmer.
   The Common Crow. All published by the United States Department of Agriculture.
   Animal Memoirs, Part II (Dr. Lockwood).
   Upon the Tree-tops (Olive Thorne Miller).
   Birds through an Opera Glass (Florence Merriam).
   Winter Sunshine (John Burroughs).
   Little Brothers of the Air (Olive Thorne Miller).
   The Play of Animals (Karl Groos).
   Bits of Bird Life (*Youth's Companion*, Supplementary Reading No. 7).

2. For study of fall flowers see books recommended for first grade.

   For helps in the study of the sweet pea, see —
   "Life Story of the Sweet Pea" in First Studies in Plant Life (George Francis Atkinson).
   For study of the clovers, see —
   Lessons with Plants (L. H. Bailey).
   Chapters in Modern Botany (Patrick Geddes).
   For study of the morning-glory, see —
   Flowers and their Friends (Margaret Morley).

3. *Trees.* (*a*) See the names of books on study of trees given in first grade.
   Nut planting, see —
   Nature Study and Life (Hodge).
   Nut Culture in the United States, United States Department of Agriculture.
   The Forest Nursery, Bulletin No. 29, United States Department of Agriculture (Bureau of Forestry).
4. *The grape.*
   Nature Study and Life (Hodge).
   Government Bulletin on Grape.
5. *Milkweed butterfly.*
   Among the Moths and Butterflies (Julia P. Ballard).
   Life Histories of American Insects (Clarence Moores Weed).
   The Butterfly Book (Dr. W. J. Holland).
   Practical Zoölogy (Buel P. Colton).
   The Milkweed Butterfly (Samuel H. Scudder).
   Everyday Butterflies (Samuel H. Scudder).
6. *Cabbage butterfly.*
   Among the Moths and Butterflies (Julia P. Ballard).
   Needham's Elementary Lessons in Zoölogy.
   The Butterfly Book (Dr. W. J. Holland).
   Stories of Insect Life (Clarence Moores Weed).
   Everyday Butterflies (Samuel H. Scudder).
7. *Dissemination of seeds.*
   Little Wanderers (Margaret Morley).
   Fertilization of Plants (Sir John Lubbock).
   Seed Travellers (Clarence Moores Weed).
   Seed Dispersal (W. J. Beal).
   Glimpses of the Plant World (Bergen).
   First Studies in Plant Life (George Francis Atkinson).
   Plant Studies (Coulter).

A Reader in Botany (Jane H. Newell).

8. *Bulbs.*

The Winter Window Garden, in *Country Life*, November, 1903.

Flowers and their Friends (Margaret Morley).

How to Study Plants (Alphonse Wood).

9. Study of Austrian pine, see —

Lessons in Science (McMurry).

Winter Term. — Second Grade

1. *Birds.* (*a*) What birds remain all winter? (In northern Illinois we have the English sparrow, blue jay, crow, prairie horned lark, screech owl, brown creeper, downy and hairy woodpeckers, junco, and chickadee.) What do they feed upon in the winter?

(*b*) As in the first grade, attract the winter birds to the school building and the homes of the pupils by furnishing a tempting bill of fare.

(*c*) Study in detail the hen.

(*d*) Study the English sparrow.

(*e*) Note the time of the return of the birds from the South. Keep a record in a note-book which the children prepare especially for the purpose.

2. (*a*) Search the woods for the March flowers. (In northern Illinois the following may sometimes be found: (*a*) hepatica, (*b*) spring beauty, (*c*) and a few dandelions. Often other varieties are to be found.)

(*b*) Study the crocus in March.

3. *Trees and vines and bushes.* (*a*) In March watch the development of the (i) lilac buds, also buds of (ii) the American elm, and (iii) box elder.

(*b*) Watch the cherry and the pear buds to see if any changes occur.

(*c*) Notice occasionally the buds of the grape-vine to see if they are swelling.

4. *Study of stones and pebbles.*

5. Make a picture of the landscape in water-colors at the beginning of each month.

6. *Good health.* To what due? (*a*) Fresh air and exercise. Breathing.

(*b*) Care of the skin. Why keep clean?

(*c*) Care of the teeth. Why?

(*d*) Care of the finger nails. Why?

(*e*) Sleep. When? How long?

(*f*) Getting the feet wet. Wet clothing and the danger.

HELPS

1. *Birds.*

(*a*) See books suggested for first year's work.

(*b*) Food of Birds.

Seed Travellers (Clarence Moores Weed).

How to Attract the Birds (Neltje Blanchan).

Nature Study and Life (Hodge).

(*c*) The hen.

Domesticated Animals (N. S. Shaler).

Animal Memoirs, Part II (Dr. Lockwood).

(*d*) English sparrows.

Lives of the Hunted (Ernest Thompson Seton).

Birds Ways (Olive Thorne Miller).

Nature Study and Life (Hodge).

(*e*) Spring migration. See books suggested the previous year.

For study of buds see books suggested the previous year.

Stones and pebbles.

First Lessons in Geology (N. S. Shaler).

Town Geology (Charles Kingsley).
How to Read a Pebble (Fred L. Charles).

Spring Term. — Second Grade

1. *Birds.* (*a*) Continue to note the arrival of the common summer residents.

(*b*) Watch for the warblers and other birds that pass through on their way north.

(*c*) Make a record in the Bird Note-book of the time at which each appears.

(*d*) Make a careful study of the robin.

(*e*) Study the nesting habits of other songsters.

(*f*) Study the red-headed woodpecker.

2. *Flowers.* (*a*) Each child make a collection of spring flowers, pressing and mounting in a book, and writing beside each flower the name and date on which it was found. Take care not to waste the flowers.

(*b*) Study the tulip.

(*c*) Follow one dandelion blossom from the time it first appears above ground through the ripening of the seed. Pupils keep a written record of what they discover.

(*d*) Study the hepatica.

(*e*) Study the wild rose.

3. *Trees and vines.* (*a*) Follow the growth of the seedlings from the acorns and nuts planted in the fall. Keep the nut bed clean and transplant the seedlings when necessary.

(*b*) Spring study of the Austrian pines and other evergreen trees.

(*c*) Follow the blossoms of the cherry buds into ripened fruit and the pear buds into fruit.

(*d*) Follow the buds of the American elm, box elder, and lilac into leaf and through blossom.

(*e*) Follow the buds of the grape until the fruit is well set.

(*f*) Care for the grape cuttings.

4. *Seed planting.* Plant in the school garden seeds of (*a*) sweet pea, (*b*) morning-glory, (*c*) sunflower, and (*d*) pumpkin. Watch and describe the development in each case. (*e*) Late in the term plant cherry pits in the school garden.

5. Get frog or toad spawn and watch the changes.

6. Make in water-colors the appearance of the landscape the first of each month.

HELPS

1. (*a*) The warblers.
    The Clerk of the Woods (Bradford Torrey).

   (*b*) Robin.
    Birds and Poets (John Burroughs).
    Upon the Tree-tops (Olive Thorne Miller).
    Birds through an Opera Glass (Florence Merriam).
    Animal Memoirs, Part II (Dr. Lockwood).
    Nestlings of Forest and Marsh (Irene Grovenor Wheelock).
    Bits of Bird Life (*Youth's Companion*, Supplementary Reader No. 7).
    The Clerk of the Woods (Bradford Torrey).

   (*c*) Nesting habits.
    Nestlings of Forest and Marsh (Irene Grovenor Wheelock).
    Bird Homes (Dugmore), Doubleday, Page & Co.
    Sharp Eyes (John Burroughs).

   (*d*) Study the red-headed woodpecker.
    The Woodpeckers (Eckstorm).
    Bits of Bird Life (*Youth's Companion*, Supplementary Reader No. 7).
    Animal Memoirs, Part II (Dr. Lockwood).
    The Clerk of the Woods (Bradford Torrey).

Nestlings of Forest and Marsh (Irene Grovenor Wheelock).

2. *Flowers.*

(*a*) Tulip.

(*b*) Dandelion.

Bailey's Lessons with Plants.

First Studies in Plant Life (George Francis Atkinson).

Flowers, Fruits, and Leaves (Sir John Lubbock).

Familiar Flowers of Field and Garden (F. Schuyler Mathews).

Little Wanderers (Margaret Morley).

Little Travellers (Clarence Moores Weed).

(*c*) Hepatica.

How to Study Plants (Alphonse Wood).

Familiar Flowers of Field and Garden (F. Schuyler Mathews).

(*d*) Wild rose, see —

Lessons in Science (McMurry).

Flowers and Ferns of United States (Thomas Meehan).

3. *Tree seedlings.*

"Life Story of the Oak" in First Studies in Plant Life (George Francis Atkinson).

4. *Buds.* See helps for previous year.

5. *Frogs and toads.*

Nature Study and Life (Hodge).

Fall Term. — Third Grade

1. *Plants of the garden and yard* (continuation of spring studies). (*a*) The sunflower. Its powers of growth during the summer. Where it is usually found. Springs up in gardens where sunflowers have grown the year before. Period of growth. Study of the great heads, size, and arrangement

of parts. Use of seeds by birds. Number of seeds; number of heads. Suggest comparison with other composite flowers in the fall; other large annuals, as corn plant, giant ragweed, mustard, etc.

(*b*) Dandelions in the fall. Tendency to spring up and blossom during summer and fall till winter begins. Due to wet weather, strong rootstock, and many buds or sprouting stems.

References.

How to Study Plants (Wood), pp. 143–147.
Handbook of Nature Study (Lange), pp. 50–57.
Plants and their Children (Dana).

(*c*) The pumpkin. Growth and extent of vines during summer and fall. Number of blossoms and pumpkins on a vine. Continuous growth and formation of new pumpkins till frost. Effects of frost. Interior structure of pumpkin. Uses to man and as feed for stock. Similarity to squashes and melons. Origin of the pumpkin; its use among Indians and pioneers. In connection with this lesson, review the planting and germination of pumpkin seeds in the spring.

(*d*) The morning-glory. Growth of vines and how they climb. Tendrils. Flowers, pods, and seeds. Shutting and opening of blossoms. Visited by insects. Effect of frosts upon the vine. Other climbing plants cultivated about the house and garden, and a brief comparison.

(*e*) Growth of seedling trees in the garden and yard (continuation). Amount of growth in length and size during the season. Differences in different kinds of seedlings: oaks, elms, maples. Note the natural springing up of different seedlings at different seasons of the year. Take care of seedlings in the garden for later transplanting.

(*f*) The grape-vine (continuation). Growth of the vine

during the season. Tendrils and climbing habit. Amount of growth. Care of cuttings. Ripening of the fruit. Kinds of fruit. Care and cultivation of the vines. Pruning. Preparation for winter. Compare vine and fruit of the wild grapevine with the cultivated varieties. Effects of cultivation.

References.

A Few Familiar Flowers (Morley).

How a Squash Plant Grows out of the Seed. Cornell Teachers' Leaflets, No. 1.

The Practical Garden Book (Bailey).

2. *The robins, bluebirds, and blackbirds in the fall* (review and continuation). Food and haunts in the fall. To what extent are they seen in the fall? Where they spend the winters. Notice the collection of great flocks of blackbirds in the fall in the groves and corn-fields. Other birds in fields and hedges. Observe the old nests and their construction.

References.

The Woodpeckers (Eckstrom).

Some Common Birds. Farmers' Bulletin, No. 54. or

First Book of Birds (Miller).

Birds of Village and Field (Merriam).

Birds of the United States (Apgar).

3. *Trees of orchard and grove.* (*a*) The apple tree. Review of spring studies. The orchard; early and late apples. Chief common kinds, size, appearance, and quality. Wormy apples and reasons. Failure of some trees to bear fruit though blossoming freely. Reasons.

References.

Nature Study and Life, Chapter XI (Hodge).

The Nursery Book (Bailey).

(*b*) Austrian pine. Amount of growth during the season. Buds. Keeping the leaves. Excursions to the grove. Seedlings. Growth of the cones. Collection of cones, buds, and needles. The evergreen grove or forest. Kinds and age of trees. Birds which nest and roost among the evergreens, as crows, woodpeckers, etc. When the needles fall. Growth of new needles.

References.

First Book of Forestry (Roth).

Trees of Northern United States (Apgar).

Nursery Book (Bailey).

Evergreens, and How they Shed their Leaves. Cornell Teachers' Leaflets, No. 13.

(*a*) *The grasshopper or locust in the field.* Life in the meadow. Movement of grasshoppers. Their food and organs. Powers of leaping and flying. Young and old. Nymphs. Their molting and growth. Collection and feeding of specimens. The life history. Depositing of eggs. Protective coloring. Enemies that feed upon them. Chickens. Migrations of grasshoppers. Their ravages. Other insects of the meadows: crickets, katydids, the walking stick.

References.

Elementary Lessons in Zoölogy. "The Grasshopper," p. 48 (Needham).

Life Histories of American Insects, Chapters VII, VIII, and IX (Weed).

Nature Study and Life (Hodge).

(*b*) Cockroaches. A pest in the house. Places infested by them. How to get rid of them.

References.

Book of Bugs (Sutherland).

Domestic Science in Elementary Schools (Wilson).

5. The kitchen. Garden vegetables brought into the kitchen. The cleaning and preparation of vegetables for the table. What vegetables require no cooking: lettuce, radishes, celery. Those requiring cooking and why, as potatoes, beets, onions, parsnips, beans, and peas. The effects of cooking on taste and quality of foods.

References.

The Chemistry of Cookery (Williams).
Domestic Science in Elementary Schools (Wilson).
The Vegetable Garden. Farmers' Bulletin, No. 94.

6. The effects of cold and frost with approaching winter. Changes in temperature measured by thermometer. Effects on gardens and vegetation. The forest. Effects upon animals. Hairy covering. Changes in clothing with approaching winter. The formation of ice in a pail. In ponds and streams. Effects of cold in the house. Heating. Uses of the thermometer. Changes in position of the sun and length of day with approaching winter.

References.

Notes on the Frost. Farmers' Bulletin, No. 104.

Winter Term. — Third Grade

1. *Pet animals and birds.* (*a*) Barnyard fowl in winter. Warm chicken houses. Pet chickens and ducks. Food: grain, waste from the table. Need of sand and gravel. Watering the fowl. Danger from extreme cold.

(*b*) Pet canary bird in cage. Care in providing bird food, water, warmth, perches, bathing dish. Observe its motions, behavior toward friends and strangers. Its fear of cats and the danger of cats. Its songs and speech. The parrot. Its food, talk, etc.

References.

Fowls, Care and Feeding. Farmers' Bulletin, No. 41.
Ducks and Geese. Farmers' Bulletin, No. 64.

2. *House plants.* Care of plants by the children.

(*a*) What house plants are kept in winter? Position at windows or otherwise. Care of house plants: heat, water, soil, sun. Geraniums and begonias. Propagating. Visit to a hothouse. How warmed. Native homes of hothouse plants. Insects infesting plants and how to deal with them.

(*b*) Tropical fruits: orange, lemon, and banana. Trees in hothouses.

References.

The Practical Garden Book (Hunn and Bailey).
Garden Making (Bailey).

3. *Uses of fire about the house.* (*a*) Heating. Effects as shown by thermometer. Kinds of fuel used: wood, hard and soft coal, oil, gas. Other combustible things. How fires are started. Matches. Kindling. Dangers from fire.

(*b*) Cooking. Several ways of cooking with fire: boiling, roasting, broiling, baking, steaming.

(*c*) Laundry use.

(*d*) Uses of chimneys, stoves. Fire-proof materials.

(*e*) Other uses of fire. In working metals. Blacksmith. Tinner. Soldering. For engines and steam.

(*f*) Source of heat in the sun.

4. *Foods and eating.* (*a*) Variety of useful foods, meats, fruits, vegetables, fish, etc. Most nourishing foods and drinks. Hurtful foods and drinks. Unripe and spoiled fruits. Bad habits in eating. Rapid eating. Not chewing food. Intemperance in eating and drinking. Use of the teeth. The care of the teeth. Structure of the teeth. Neglect and injury to the teeth. Advice of a dentist in

regard to the teeth. Excessive eating of candies and sweetmeats. Poorly cooked foods. How cooking improves foods. Good manners at the table. The decoration of the table with flowers and fruits.

References.

Foods, Nutritive Value and Cost. Farmer' Bulletin, No. 23.

Domestic Science in Elementary Schools (Wilson).

5. *Signs of returning spring.* (*a*) Days growing longer. Sun higher. Sunset points.

(*b*) Breaking up of ice; melting of snows; floods.

(*c*) Returning of birds. Examples: robin, meadow-lark, bluebird, song-sparrow.

Early plants and flowers. Crocus, tulip, anemone, hepatica (review).

Birds departing for the north, chickadee, snowbirds, etc.

(*d*) Trees. Sap running, buds swelling. Willow.

(*e*) Animals coming from winter homes. Squirrels, frogs, turtles, insects.

(*f*) Changes in the appearance of the woods and fields.

(*g*) Average temperature out of doors. Thermometer.

(*h*) Cloudy and rainy weather. Bad roads, mud.

(*i*) Grass on lawn and fields takes on a green tint.

(*j*) Cause of all these changes.

(*k*) Effects upon people. Preparation of farmers and gardeners for spring work.

6. *The window garden in March.* Boxes and soil. Germination of garden and flower seeds. Care of growing plants. Transfer to school garden later.

References.

The Practical Garden Book (Hunn and Bailey).

Garden Making (Bailey).

Plants and their Children (Dana).

Spring Term. — Third Grade

1. *The garden.* (*a*) The school garden. Preparation of the soil. Planting of beans, peas, corn and potatoes, four-o'clock and aster.

Careful cultivation. Weeds and grasses. Notice effects of weather, storms, warm days, etc. Watch growth of the plants. Continue study of these in fall.

(*b*) Encouragement of home gardens. Visit such gardens and compare with school garden. The home garden may be continued more easily through the summer.

(*c*) Visit larger gardens and notice modes of cultivation, tools, results, etc.

(*d*) Special study of plants being raised in the garden, as to seed, soil, cultivation, grubs and insects injurious to plants. Caterpillar on parsnip and parsley.

(*e*) The potato plant. Underground stem and tubes. The blossom. The potato-beetle. Its harm, and how to destroy it.

References.

Garden Making. Suggestions for utilizing Home Grounds (Bailey).
The Practical Garden Book (Bailey).
The Soil (King).

2. *Roadside and field plants.* (*a*) Plantain, curly dock, wild parsnip, dandelion, daisy-fleabane, sweet clover, and other rootstocks. Early spring plants which are perennials. Excursions to find and dig up these rootstocks. Rhubarb and horse-radish in gardens. Study in class of the rootstocks. Where do these plants flourish best ?

(*b*) Trace the growth of these plants during the spring season to flower and fruit so far as possible.

(*c*) Contrast these plants with the annuals. Continue into the fall.

3. *The orchard and bush fruits.* (*a*) Peaches and plum trees. Planting and raising of seedlings. Buds and blossoms. Frosts. Development of young fruit. Visits of insects to flowers.

(*b*) Blackberry and raspberry. Propagation. Roots and underground stems. Young shoots and old stalks. Blossoming and fruit. Young plants, how started.

(*c*) Garden weeds. Milkweed. Underground stem. Other weeds and their roots.

References.

Weeds and How to Kill Them. Farmers' Bulletin, No. 28.

The Peach-tree Borer. Farmers' Bulletin, No. 80.

The Nursery Book (Bailey).

Garden Making (Bailey).

4. *Birds of the orchard and garden.* (*a*) The mourning dove; nest. The blue jay; habits, food. The humming-bird; honeysuckle, trumpet-vine, columbine. Wren, chickadee, bluebird, woodpecker. Baltimore oriole; nest. The scarlet tanager. Yellow warbler. Rose-breasted grosbeak.

(*b*) Making of bird-houses for different birds. Bird enemies: snakes, cats, and owls.

(*c*) The insects — plant lice, caterpillars, borers — and seeds and fruits devoured by the birds. Quarrels among the birds.

References.

Animal Memoirs, Part II, "Birds" (Lockwood).

Everyday Birds (Torrey).

Some Common Birds. Farmers' Bulletin, No. 54.

The Birds and I. Cornell Teachers' Leaflets, No. 10. (Bailey).

5. *Shade trees.* (*a*) The maple. Early buds, blossoms, winged seeds, and leaves. Flow of sap. Sugar making.

(*b*) The oak. Long-hanging catkins, small green buds of pistillate flowers. Growth of the acorns. Sprouting of old acorns in the soil. Leaves.

(*c*) The birch. Its peculiar bark. Catkins.

(*d*) Catalpa and honey locust. Blossoms and leaves of special interest. Study the same trees again in the fall.

References.

Familiar Trees and their Leaves (Mathews).
The Common Trees (Stokes).
Trees of the Northern United States (Apgar).
Guide to the Trees (Lounsberry).

6. *The lawn.* (*a*) Making a lawn. Sowing grass seed. Kinds of grasses. Blue grass. Clover.

(*b*) Weeds. Dandelion, plantain, wild grasses, crab grass, pigeon grass, ragweed, knotweed, chickweed.

(*c*) Watering the lawn. Plenty. The rain. The earthworm.

(*d*) The mole. Burrowing. Food and habits of the mole. Organs. Castor beans planted to prevent moles.

(*e*) Shrubbery: lilac, snowball, sumac, syringa, spirea, bridal-wreath, Japan quince, flowering almond, honeysuckle.

(*f*) Birds frequenting the lawn. Robin searching for earthworm and caterpillars. English sparrow. Dandelion heads.

References.

Garden Making, Suggestions for utilizing Home Grounds (Bailey).
The Practical Garden Book (Bailey).

Fall Term. — Fourth Grade

1. Continue plant studies of spring as follows: (*a*) maple, oak, birch, catalpa.

(*b*) Fruit trees and blackberry.

(*c*) Roots of dock, dandelion, sweet-clover, etc.

(*d*) Garden vegetables.

References.

The Vegetable Garden. Farmers' Bulletin, No. 94.
Guide to the Trees (Lounsberry).
Stories of the Trees (Mrs. Dyson).
The Common Trees (Stokes).

2. *The corn plant* (review previous studies). (*a*) Full stalk of field corn for study. Visit garden and corn-fields in September. The nodes and internodes on the stalk. Arrangement and uses of blades. The ear and its stalk. Arrangement of ears. Silk and tassel. Roots and the cultivation of corn. Soils and productiveness. The corn-worm; chinch-bug. Experiments in cultivating the corn plant. Rust and the effects of weather. History of corn plant among Indians and whites. Kinds of corn in common use.

(*b*) Grasses: timothy, blue grass. Resemblances to corn.

(*c*) Grains: wheat, oats, rye, barley.

References.

Corn Plants, their Uses and Ways (Sargent).
Principal Insect Enemies of Growing Wheat. Farmers' Bulletin, No. 132.
Agriculture for Beginners (Burkett, Storms, and Hill).

3. *Weeds of garden and field.* (*a*) Milkweed. Pods and seeds. Seed dispersal.

(*b*) Butter print (velvetweed); flowering and seed. Amarinth (pigweed).

(*c*) Cocklebur; vigor of the plant; seed production. Lamb's-quarters.

(*d*) Ragweed and purslane.

(*e*) Fox-tail grass; quick (quack) grass.

(*f*) Burdock; mullein in meadows and pastures.

(*g*) Bindweed or wild morning-glory. Difficulties in ridding fields of weeds because of abundance of seeds, scattering and distribution of seeds, tough hardy plants and roots.

(*h*) Birds as seed destroyers.

References.

Weeds and How to Kill Them. Farmers' Bulletin, No. 28.

Nature's Garden (Blanchan).

The Children's Garden (Bailey). Cornell Teachers' Leaflets.

Seed Dispersal (Beal).

4. *Kinds of rocks.* (*a*) Pebbles from the stream. History of the pebble. The boulder.

(*b*) Limestone. Marble. Fossils. Coral. Sandstone. Rindstone. Stratified rock.

(*c*) Quartz. Granite. Igneous rocks. Lava. Clays.

(*d*) Making of concrete walks.

(*e*) The decay of stones by weathering. Foundations of buildings. Monuments. Experiments with acids on stones. Formation of soils from rock decay. Rich and poor soils.

(*f*) Collections of specimens and grouping.

References.

How to Read a Pebble (Charles).

Town Geology (Kingsley).

About Pebbles (Hyatt).
Common Minerals and Rocks (Crosby).

5. *Common stars and constellations.* (*a*) Big dipper and north star. The stars as guides to sailors and travellers.

(*b*) Orion, Cassiopeia. The dog star. Pleiades. The apparent movement of the constellations at night.

(*c*) The planets. Jupiter. Venus. Changing position.

(*d*) The moon and its changes. Observation of the cycle of four weeks.

(*e*) The changes of position of the constellations with the seasons.

References.

Astronomy by Observation (Bowen).
The Story of the Stars (Chambers).
Unography. The Constellations Visible in the United States (Young).
Starland (Ball).
Familiar Talks on Astronomy (Parker).

6. *The larger birds.* (*a*) Habits, food, eyes, claws, night habits. Relation to other birds and animals.

(*b*) Hawk. Kinds of hawks and their prey; chicken hawks; fish hawks. Owls.

(*c*) The eagle. Its nesting places. Its power of flight and strength. Food. The eagle as a national emblem.

(*d*) The buzzard. A scavenger. Laws protecting it.

References.

Citizen Bird (Wright and Coues).
The First Book of Birds (Miller).
Neighbors with Wings and Fins (Johonnot).
Birds of the United States (Apgar).

7. *Cleanliness in kitchen.* (*a*) A model kitchen and pantry. The chemistry of cleaning. Utensils. Solvents of grease.

(*b*) Flies. Means of ridding the kitchen of them, — screens, poison paper, etc. The breeding places. Cleanliness in back yard. Danger of flies in dining room and kitchen. Their feet as means of carrying germs.

(*c*) The sink. Construction and how kept clean. Soap, sapolio. The trap and its uses. Disinfectants. How used.

(*d*) The mould on bread and fruit.

(*e*) Soap. The uses of soap. The making of soap. Its ingredients.

References.

The Chemistry of Cleaning and Cooking (Richards and Elliott).

Handbook of Household Science (Youmans).

Domestic Science in Elementary Schools (Wilson).

Winter Term. — Fourth Grade

1. *Common tools and inventions.* (*a*) The crowbar. The lever and its uses.

(*b*) The plane. Planing machines, machines for planing wood and iron.

(*c*) The screw. The jack-screw, various uses. Work bench.

(*d*) The wheel and axle. Axle grease and friction. In wagons.

(*e*) Rope and pulley. Uses in barns and warehouses.

(*f*) The steel in edged tools. Grindstone. Ideas involved in chest of tools.

(*g*) The life preserver. Materials. Specific gravity of water, wood, cork, etc.

(*h*) The derrick and its construction and use. Observe in quarries and shops.

(*i*) The turning lathe and its uses.

References.

Text-books in Physics.
Experimental Science (Hopkins).

2. *Water in its various forms and uses.* (*a*) Uses of common water to plants, animals, and man.

(*b*) Steam and its nature. Uses. Steam for power, cooking, heating, etc. Evaporation.

(*c*) Ice. Effects of freezing. Uses of ice. Snow, sleet.

(*d*) Water as a solvent.

(*e*) Sources of pure drinking water. Causes of impurity and disease. Filtering; distilling.

(*f*) Mineral springs. Rivers. The ocean.

(*g*) Water vapor in the air. Rain, snow, etc.

References.

Popular Readings in Science (Gall and Robertson).
On Forms of Water (Tyndall).
Municipal Engineering and Sanitation (Baker).

3. *The skin and its uses to the body.* (*a*) Structure and parts of the skin. The pores. Perspiration.

(*b*) Keeping the pores open by exercise, by rubbing.

(*c*) Bathing. The office of the skin. Effects of cold and hot bathing.

(*d*) Sudden changes. Colds and catarrhs.

References.

Our Bodies and How We Live (Blaisdell).
Graded Lessons in Hygiene (Krohn).
Text-books in Physiology and Hygiene.

4. *The metals.* (*a*) The common metals. Collect specimens of pure metal and crude ores.

(*b*) Lead. Melting and moulding of lead. Its various uses due to its qualities. Lead poisoning.

(*c*) Iron and its qualities. Reduction of ores. Steel and its qualities. The simple magnet. Modes of making steel.

(*d*) Gold and silver. Smelting of ores. Use of quicksilver. Value of chemistry in the reduction of ores.

(*e*) Copper. Tin and zinc.

(*f*) Aluminum. Its source from clay.

References.

Economic Geology of the United States (Tarr).

Text-book of Mineralogy (Dana).

5. *Trees in winter.* (*a*) Effects of cold upon trees. Barren appearance. Frost in the fall, nipping and shrivelling some leaves as catalpa. Killing of the long, tender shoots of the willow, box elder, and other trees, by cold. Killing of fruit trees and even forest trees by extreme cold. The breaking of boughs by sleet and snow. The uprooting of trees by storms.

(*b*) The buds in winter time. The buds wrapped to protect against sudden changes.

(*c*) Preparation of the buds in February and March for coming spring. The sap in trees in spring.

References.

How Trees Look in Winter (Bailey). Cornell Teachers' Leaflets, No. 12.

First Book of Forestry (Roth).

Hutchinson's Study of Trees in Winter.

6. *Budding and grafting of fruit trees.* (*a*) Study of twigs to note yearly growth. Leaf buds. Apple, pear, peach.

(*b*) Difference between seedlings and grafted or budded fruits. The process of grafting and budding as seen in a nursery.

(*c*) New varieties of fruit obtained from seedlings. The development of choice varieties by selection and cultivation.

References.

The Apple and How to Grow It. Farmers' Bulletin, No. 113.
Nature Study and Life (Hodge).
The Nursery Book (Bailey).

7. *Temperance in eating and drinking.* (*a*) Healthful foods and moderation in eating.

(*b*) Bad effects of alcoholic drinks.

(*c*) The uses of milk.

(*d*) Tea and coffee.

References.

Applied Physiology (Overton).
How to Keep Well (Blaisdell).
Physiology and Hygiene (Hutchison).

Spring Term. — Fourth Grade

1. *Wild spring flowers in the woods.* (*a*) A calendar of the spring flowers. Time and place of first appearance.

(*b*) Spring beauty, water leaf, violets, mandrake, Solomon's seal, trillium, the ferns, wild geranium. Dependence of forest plants on shade and protection of trees.

(*c*) Transfer of plants to the school and home garden. Soils suited to various plants. Flower garden. Leaf mould, and soil.

(*d*) Care against waste and destruction of wild plants.

References.

Nature Study by Months (Boyden).

2. *Tree study in early spring* (*April*). (*a*) Excursions into the woods. Recognition of trees by size, outline, framework, bark, and buds. Colors and marking of stems. Size of buds on hickory, cottonwood, elm, maple, etc.

(*b*) Collection of specimens of buds, bark, and of sections of wood.

(*c*) Drawings of framework and branching of trees.

References.

How Trees Look in Winter. Cornell Teachers' Leaflets, No. 12.

Hutchinson's Study of Trees in Winter.

3. *The tame duck and goose.* (*a*) The duck pond. Swimming and diving of the ducks. The uses of their feet, bill, feathers, eyes. The waddling of ducks on land. Food and care of ducks in winter. Nesting places and hatching. Young ducks. Value of ducks as poultry.

(*b*) The goose. Feeding in the meadows and in water. Size and value of the eggs. Use of the feathers. Compare with the duck. Compare with the chicken.

References.

Ducks and Geese. Farmers' Bulletin, No. 64.

4. *Poisonous plants in the woods.* (*a*) Kinds of poisonous plants in the woods: poison ivy, poison oak, poison hemlock, poison sumac. The effect of this poisoning upon the skin and mode of treatment.

(*b*) Mushroom. Difficulty of distinguishing between the edible and poisonous kinds.

(*c*) Choke-cherry, buckeye, wild parsnip.

(*d*) Nettles, smartweed.

References.

Thirty Poisonous Plants. Farmers' Bulletin, No. 86.
Nature Study and Life (Hodge).
Mushrooms (Gibson).

5. *The care of chickens in spring* (by children). (*a*) Observe and care for hens and chickens in springtime. Their enjoyment of the warm spring sun. The dust bath. Crowing, cackling. Hunting for worms and insects in the yard and in the fresh-ploughed garden. The nesting and setting of hens. Time needed for hatching. Hatching out of chicks. The chicken-coop. Care and protection of the mother hen for her chicks. Scratching for food. Danger to chicks from rats, hawks, cats, etc. Feeding the hen and young chicks. Water. Rainy weather. Review of feet, bill, feathers, crop, gizzard, wings.

(*b*) The pigeons and the pigeon-house. Cooing. Hatching and feeding of young. The food, flight, and habits of pigeons.

References.

Fowls: Care and Feeding. Farmers' Bulletin, No. 41.

Standard Varieties of Chickens. Farmers' Bulletin, No. 51.

Squab Raising. Farmers' Bulletin, No. 177.

6. *The meadow flowers.* (*a*) The grasses: timothy, blue grass. The blossom and seeds. Their value to farmers and for lawns. The white and red clover. Roots of clover and value to the soil. Bees and honey in clover.

(*b*) The meadow rue, primrose, fleabane, meadow lily, purple cone flower, buttercup, marsh marigold.

(*c*) Wild rose; study of the blossom; compare with cultivated roses.

References.

The Corn Plants: their Uses and Ways of Life (Sargent).

Ten New England Blossoms (Weed).

7. *A clean cellar.* (*a*) The proper drainage of the cellar and cellar walls. Cementing walls. Orderliness.

(*b*) Cement floors. Washing and cleaning and drainage of floors.

(*c*) Vegetable cellar. Decaying fruits and vegetables.

(*d*) The laundry tubs and wash water.

(*e*) Ventilation and drying out of cellar at intervals.

(*f*) Dust, paper, rags, and rubbish. Ashes, coal dust, spontaneous combustion.

(*g*) Rats and mice; traps.

(*h*) Whitewash and disinfectants.

Fall Term. — Fifth Grade

1. *Pond life in the fall.* (*a*) The turtle. Shell and peculiar structure. Life history; habits. Food, and how obtained. Hibernation in fall and winter.

(*b*) The muskrat. Food, and life in water. Preparation for winter. Organs. The muskrat house. Materials and construction.

(*c*) Tame ducks and geese. Life in water. Feet, bill, and feathers. Food. Nesting. The young. Compare with wild ducks and geese.

(*d*) Mosquitoes in late summer and fall. Excursion to the pond. Metamorphosis of mosquito in pond. Collect eggs, and hatch. Modes of protection against mosquitoes. Means of destroying them. Disease germs carried by mosquitoes.

(*e*) The crab.

(*f*) Tree and other plant life about the pond. Rushes, sedges, and coarse grasses.

(*g*) An aquarium. Care of plants and animals in aquarium.

References.

Nature Study and Life (Hodge).
Ducks and Geese. Farmers' Bulletin, No. 64.
In Brook and Bayou (Bayliss).
Life in Ponds and Streams (Furneaux).
Lessons in Zoölogy (Needham).

2. *Birds that feed upon weed seeds.* (*a*) The abundance of weed seeds in fields and by roadsides. Kinds of weeds. Collection of samples of seeds.

(*b*) Birds useful as weed destroyers. The junco and other sparrows. The blackbird. The snowbirds. Finches and quails. The English sparrow. Observing birds when feeding.

(*c*) The effect upon farms, gardens, and lawns.

References.

Nature Study and Life (Hodge).
Birds as Weed Destroyers. Bulletin.

3. *Orchard.* (*a*) The apple tree. Cultivation of the apple. Pruning and trimming of trees.

(*b*) Insects injurious to apple tree. Codling moth. Collections for spring. Apple-tree borer. Tent-caterpillar, (follow next spring).

(*c*) Peach trees. Care of trees; pruning. Budding in fall. Cutworms and how to avoid them.

References.

The Codling Moth, Bulletin 142, Cornell University.
The Peach-tree Borer, Bulletin 176.
The Evolution of our Native Fruits (Bailey).

The Apple, and How to Grow It (Brackett). Farmers' Bulletin, No. 113.

Life Histories of American Insects (Weed).

The Peach-tree Borer. Farmers' Bulletin, No. 54.

Important Insecticides. Farmers' Bulletin, No. 19.

Spraying Fruit Diseases. Farmers' Bulletin, No. 38.

Apple Twigs (Bailey). Cornell Teachers' Leaflets, No. 3.

4. *Inventions and Instruments.* (*a*) The stove. Furnace. Lamp. Structure; ventilation; air; oxygen in the air necessary to fire.

(*b*) The thermometer. Construction; expansion due to heat; scientific and common uses of thermometer. Other illustrations of expansion and contraction.

(*c*) The compass. Magnetic needle; uses in navigation, etc. History of its early use and value.

References.

Lessons in Physics (Lothrop and Higgins).

Other Text-books in Physics.

The History of Physics (Cajori).

5. *The cooking of starchy foods.* (*a*) The starch in plants: potato, corn, rice, wheat, etc. The starch test. Starch and sugar. Chemical elements in starch.

(*b*) Effect of cooking upon starchy foods. Boiling potatoes; cooking rice. Recipes for cooking vegetables.

(*c*) The digestion of starchy foods. Value of starch for heat; energy and fat.

References.

Domestic Science in Elementary Schools, Chapter III (Wilson).

Elements of the Theory and Practice of Cookery (Williams and Fisher).

The Chemistry of Cookery (Williams).
Colton's Physiology.

6. *Minerals.* (*a*) Salt. Nature of salt. Salt deposits. Uses of salt in food as preservative. Solution in water. The ocean saltness. Manufacture of salt by evaporation.

(*b*) Lime. Lime in water. Hard water. Limestone. The lime kiln. Lime as a soil maker. The limestone quarry.

References.

First Lessons in Minerals (Richards).
Observation Lessons in Common Minerals (Clapp).
Common Minerals and Rocks (Crosby).

Winter Term. — Fifth Grade

1. *Tobacco and its uses.* (*a*) The tobacco plant. Nicotine as a poison.

(*b*) Cigarettes and how made. The effects of smoking cigarettes by boys. Physical and mental effects. Testimony of physicians. The slavish influence of bad habits.

(*c*) The economy of the tobacco habit.

(*d*) Tobacco smoke used on plants to destroy plant lice, etc.

References.

Our Bodies and How We Live (Blaisdell).
Applied Physiology (Overton).

2. *Winter birds.* (*a*) Observe and make a note of birds which remain during the winter. Study especially the three following groups: —

(*b*) Seed consumers: sparrows, snowbirds, English sparrows, quail, snowflake, tree-sparrow.

(*c*) Insect eaters: woodpeckers, chickadee, brown creeper, nuthatch.

(*d*) Birds of prey: hawks, eagles, etc.

(*e*) Feeding the birds in winter. Effects of severe weather, as icy and sleet weather, upon birds. Feeding of birds with crumbs, grain, and suet.

(*f*) Trees and shrubs which supply food to birds in winter: choke-cherry, hackberry, elderberry, cedar, juniper, etc.

References.

Nature Study and Life (Hodge).
Birds of Village and Field (Merriam).
Life of Audubon, the Naturalist.
The First Book of Birds (Miller).

3. *Inventions.* (*a*) The water-wheel as a mechanical power. Construction and use as source of power.

(*b*) The wind-mill. The machinery by which the power is made available for pumping, etc.

(*c*) Gunpowder and explosive ingredients. Uses of gunpowder. Blasting. Rifle and shot-gun; care and use. Danger of toy pistols, firecrackers. Heavy ordnance.

(*d*) The reaper as a labor-saving machine. The value of these inventions for increasing production and cheapening products.

References.

Text-books in Physics.
Progress of Invention in the Nineteenth Century (Byrn).
History of Physics (Cajori).

4. *Stories of hunting and life of wild animals.* (*a*) Large game in America: buffalo, deer, elk, beaver, bear, grizzly, eagle, turkey, alligators, the green turtles.

(*b*) Stories of famous hunters and their adventures in hunting big game.

(*c*) Descriptions of the homes, haunts, and habits of these animals in their wild state.

(*d*) Preserves of wild animals of North America.

(*e*) Zoölogical gardens in large cities.

References.

Stories of Animal Life (Holder).
Wilderness Ways (Long).
Natural History in Anecdote (Miles).
Training of Wild Animals (Bostock).
American Animals (Stone and Gram).
Lives of the Hunted (Seton).
Wild Beasts (Porter).

5. *The teeth.* (*a*) Kinds of teeth: incisors, canine, premolars, molars. First teeth.

(*b*) Teeth of animals previously studied: dog, squirrel, ox, horse, cat. Food required for each kind.

(*c*) Structure of the teeth. Enamel. Wrong uses of the teeth.

(*d*) Cleansing teeth. Brush, powder.

(*e*) Dentistry and treatment of teeth. Advantage of skilled specialists.

(*f*) Chewing of food. Kinds of food that need thorough chewing.

References.

Our Bodies and How We Live (Blaisdell).
Text-books in Physiology.

6. *Weather study in the spring.* (*a*) Record of weather observations. Temperature and cloudiness. Use barometer and thermometer. Notice and compare reports of weather bureau.

(*b*) Observations and experiments on evaporation. How clouds are formed in the sky. The rain storm. Hail. Movement of moisture from ocean to cloud and return to ocean.

(*c*) The thunder-storm. Lightning and electricity. The story of Franklin and the kite.

(*d*) Effect of weather conditions upon garden and farm. Too much moisture or drought.

References.

A Summer Shower (Tarr). Cornell Teachers' Leaflets, No. 14.
About the Weather (Harrington), Appleton & Co.
Elementary Meteorology (Waldo).

Spring Term. — Fifth Grade

1. *The forest trees.* (*a*) Tree calendar. The leafing out of different trees. Their blossoms and leaves. The oak; staminate and pistillate blossoms. The hickory, the basswood, the chestnut.

(*b*) The crab-apple, the haw, the hackberry, the wild cherry, birch, sycamore, the tulip, the mulberry, the persimmon, the paw-paw.

(*c*) The evergreens in spring. Study of the white pine.

(*d*) The natural propagation of trees in the woods. Seedlings of different kinds of trees.

References.

A Year among the Trees (Flagg).
Familiar Trees and their Leaves (Mathews).
The Common Trees (Stokes).
The Stories of the Trees (Dyson).
Succession of Forest Trees and Wild Apples (Thoreau).
Trees of the Northern United States (Apgar).

2. *Bees.* (*a*) Honey-bee. Observation of bees among the flowers. White clover, pollination. Effects.

(*b*) The hive; its construction and arrangement. Flowers from which bees collect honey. Moth and other enemies.

(*c*) Different kinds of honey-bees.

(*d*) Range of bees and habits in collecting honey. Uses to greenhouses.

(*e*) The bumblebees. Their nests and food. Red clover. Life history.

(*f*) Hornets and wasps. Paper making.

(*g*) List of flowers visited by bees.

(*h*) Value of bees to gardeners and fruit growers.

References.

> Bee-keeping. Farmers' Bulletin, No. 59.
>
> The Honey Makers (Morley).

3. *The pond.* (*a*) The common frog. Early appearance in spring. Frogs' eggs. Hatching. Tadpoles. Food and growth. Noises. Mouth, legs, and feet. Swift movement in water. Enemies of the frogs, as fishes, water-birds, snakes. Means of escape.

(*b*) Treatment and feeding frogs in the aquarium. Resemblance of aquarium to pond.

(*c*) Salamanders, newts, lizards.

(*d*) Managing an aquarium.

References.

> The Frog (Marshal).
>
> Life in an Aquarium (Rogers). Cornell Teachers' Leaflets, No. 11.
>
> Nature Study and Life (Hodge).
>
> Elementary Lessons in Zoölogy (Needham).

4. *The house cat.* (*a*) Habits of the house cat in hunting for mice, birds, etc.

(*b*) How the cat is able to provide for itself by its feet, teeth, tongue, whiskers, eyes, and fur.

(*c*) Why cats are kept as pets.

(*d*) The cat as an enemy to useful birds.

(*e*) The close kindred of the cat among the wild animals: wildcat, tiger, cougar.

References.

Chapters on Animals (Hamerton).
Introduction to Zoölogy (Schmeil).
Text-books of Zoölogy.

5. *The ox, its food and organs.* (*a*) Grazing in the pastures. Habits of cud chewing.

(*b*) The mouth and teeth of the ox. Other food, as corn, fodder, root crops, etc.

(*c*) The stomachs of an ox. Uses of the different stomachs.

(*d*) Oxen as draft animals.

(*e*) Other cud-chewing animals: sheep, deer, buffalo, goat.

(*f*) Contrast of ox with horse and with dog and cat.

References.

Practical Zoölogy (Colton).
Practical Biology (Huxley and Martin).

6. *The nursery and the orchard.* (*a*) Seedlings of apple, pear, peach, cherry, etc. Plant seeds and cultivate seedlings. Many seeds are best planted in the fall in preparation for spring study.

(*b*) Planting of fruit trees in the orchard. Soil and arrangement of trees. Spacing.

(*c*) Planting of shade trees. Value of different shade trees.

(*d*) Pruning and care of trees. Use of seed collected in the fall.

(*e*) The wild cherry. Flower and fruit. Food for birds.

(*f*) Insects hurtful to fruit trees and shade trees. Leaf crumpler, moths, tent-caterpillar. Gall nuts.

References.

Three Insect Enemies of Shade Trees. Farmers' Bulletin, No. 99.

The Apple and How to Grow It. Farmers' Bulletin, No. 113.

The Common Trees (Stokes).

The Nursery Book (Bailey).

Fall Term. — Sixth Grade

1. *Review and continuation of spring studies.* (*a*) The forest trees. Nuts and fruits in the fall. Leaf coloration and leaf fall; calendar. Collect and tabulate changes in foliage. Season's growth of different kinds of trees; of hardwoods and evergreens.

(*b*) Bees in the fall. Late blossoms visited. Store of honey for winter. Changes in the life of the hive.

References.

Trees of the Northern United States (Apgar).

Our Native Trees (Keeler).

The Oak (Ward).

Bee-keeping. Farmers' Bulletin, No. 59.

2. *Pure water.* (*a*) The water supply of houses. Wells and their dangers. Bored wells. Springs. Cisterns. Former epidemics. Cholera.

(*b*) City water supplies. Dangers of contamination.

(*c*) Diseases springing from impure water. Fevers. Diphtheria.

(*d*) Filters. Distilled water.
(*e*) Bacteria. Their propagation.
(*f*) Testing water. The state chemist.

References.

Municipal Engineering and Sanitation (Baker).
Popular Readings in Science (Gall and Robertson).
School Hygiene (Shaw).
Story of Germ Life (Conn).

3. *The farm.* (*a*) The cultivation of grains and grasses on the farm. Proper modes of cultivation. Machines used.

(*b*) Soils. Poor and rich soils. Rotation of crops. Exhaustion of soils. Value of clover and grasses. Fertilizing with manures and artificial fertilizers. The effect of drainage upon soils and plants. Laboratory experiments with soils.

(*c*) Insect pests of the farmers: chinch-bug; grasshopper, Hessian fly. Scientific methods of dealing with pests.

(*d*) Feeding and fattening of farm stock. The silo as a means of food preservation and supply. The diseases of farm animals and their treatment. The veterinary surgeon.

(*e*) The value of science to the farmer.

(*f*) The agricultural colleges and the state experiment stations. Their uses to the farmer.

References.

The Principal Insect Enemies of Growing Wheat (C. L. Marlatt). Farmers' Bulletin, No. 132. Government Printing-office.
The Soil (King).
Silos and Silage, Farmers' Bulletin, No. 32.
The Farmer's Interest in Good Seed. Farmers' Bulletin, No. 111.

Practical Agriculture (James).
Meadows and Pastures. Farmers' Bulletin, No. 66.
Commercial Fertilizers. Farmers' Bulletin, No. 44.
Sewage Disposal on the Farm. Farmers' Bulletin, No. 43.
Farm Drainage. Farmers' Bulletin, No. 40.

4. *The pond in the fall* (continued). (*a*) The toad: life history; its food; uses in the garden.

(*b*) Fishes: the perch, carp; life histories; spawning; food of fishes; mode of breathing · structure and organs of the fish. The flesh of fish.

(*c*) The aquarium for fishes.

(*d*) Fish laws in the state.

(*e*) The fisheries commission at Washington. Stocking of lakes and rivers with fish.

References.

Nature Study and Life, Chapter XVI (Hodge).
Life in Ponds and Streams (Furneaux).
American Food and Game Fishes (Jordan and others).

5. *Temperance.* (*a*) Beer. Grains. Fermentation. The alcohol in beer.

(*b*) Wine. Process of making wine.

(*c*) Nature of alcohol. Experiments.

(*d*) Cider and vinegar. Hard cider.

(*e*) Uses of fermented liquors and their effects.

References.

Applied Physiology (Overton).
Graded Lessons in Hygiene (Krohn).
Our Bodies and How We Live (Blaisdell).

6. *Cooking.* (*a*) Meats. Value of different meats as food. Proteids and their muscle-building service.

(*b*) Cooking meats: boiling, broiling, and roasting.

(*c*) Canned meats and extracts.
(*d*) Soups from meats; their value as foods.
(*e*) The cooking of chickens, turkeys, and ducks.
(*f*) Gravy and sauce with meats.

References.

Meats, Composition and Cooking. Farmers' Bulletin, No. 34.
Domestic Science in Elementary Schools (Wilson).
Elements of the Theory and Practice of Cookery (Williams and Fisher).
The Chemistry of Cleaning and Cooking (Richards and Elliott).

7. *Visit to a zoölogical garden as a preparation for winter studies.* A topic suitable to larger cities. (*a*) The dens of wild animals.
(*b*) The aviary.
(*c*) The fishes.
(*d*) The serpent house.

Winter Term.—Sixth Grade

1. *Coal and its origin.* (*a*) Nature and uses of coal. Specimens examined. Kind of coal.
(*b*) How coal was formed in the earth. The coal strata. How situated.
(*c*) The carbon in coal.
(*d*) Coal gas; how obtained; use; coke; dangers from gas. Natural gas.
(*e*) Petroleum. Various by-products.

References.

The Story of a Piece of Coal (Martin).
Coal and Coal Mines (Greene).
The Geological Story briefly Told (Dana).

2. *Inventions and instruments.* (*a*) Sewer connection with street. Wash-basins. Soil-pipe. Traps. Bathroom. Danger of sewer-gas. Disinfectants.

(*b*) The hydrostatic press. Construction and value.

(*c*) The steam-engine. The power derived from steam. Its various uses.

(*d*) Fire-proof constructions. Brick and tile. Asbestos. Paint.

(*e*) The telescope; construction and use. Lenses.

(*f*) The clock; pendulum.

(*g*) The ice-making machine.

References.

Handbook of Household Science (Youmans).
Progress of Invention in the Nineteenth Century (Byrn).
Municipal Engineering and Sanitation (Baker).
The regular text-books on Physics.

3. *The sun; light and heat.* (*a*) The sun; size and distance and relation to earth.

(*b*) Light. Nature of light. Undulations. Speed of movement. Laws of light. The prism. The rainbow.

(*c*) Heat. Heat rays, illustrated. Effects of heat upon soil, rocks, etc. Effect upon the atmosphere. Effects upon oceans, lakes, and seas. Plant and animal life dependent upon the sun.

(*d*) Heat a source of power.

References.

Story of the Solar System (Chambers).
Starland (Ball).
The Sun (Young).
Tarr's Physical Geography.

4. *The digestive system.* (*a*) The digestive tract as a whole.

(*b*) Mastication; the teeth; salivary glands.

(*c*) The stomach.

(*d*) Liver and pancreas.

(*e*) The intestinal digestion.

(*f*) The relation of digestion to cooking.

(*g*) Effects of alcoholic beverages on digestion.

(*h*) Temperance and moderation in eating a basis of good health.

References.

Physiology and Hygiene (Hutchinson).
Lessons in Elementary Physiology (Huxley).
The Human Body (Newell).
Other text-books on Physiology.

5. *Contagious diseases.* (*a*) Smallpox and vaccination.

(*b*) Diphtheria; antitoxin.

(*c*) Measles. Whooping-cough. Public regulations in schools.

(*d*) Disinfecting rooms; best means used.

(*e*) Quarantining by city and state or nation. Health officers. State board of health.

References.

School Hygiene (Shaw).
School Sanitation and Decoration (Burrage and Bailey).
Domestic Science in Elementary Schools (Wilson).

6. *The study of wild animals* (continuation). (*a*) The zoölogical garden (in cities).

(*b*) The school "zoo" and home pets.

(*c*) Hunting and large game in Africa. Elephants, lions, ostrich, antelope, giraffe.

(*d*) Homes and habits of these wild animals in the wild state.

(*e*) Books of travel, adventure, and description.

References.

Wild Neighbors (Ingersoll).
Story of the Red Deer (Fortescue).
Wilderness Ways (Long).
Natural History in Anecdote (Miles).
Stories of Animal Life (Holder).
Wild Animals I have known (Seton).

7. *Eyes and ears.* (*a*) Structure and parts of the eye. Modes of testing the vision. Frequency of weak or defective eyes.

(*b*) Value and use of glasses. The field glass.

(*c*) Necessity of consulting specialists, as oculists.

(*d*) Structure of the ear for receiving sound. Defective ears and hearing.

(*e*) Instruments to aid hearing.

(*f*) State institutions for the care and education of the deaf and blind. Learning to read, write, and talk.

References.

Our Bodies and How We Live (Blaisdell).
Lessons in Elementary Physiology (Huxley).
Other physiology text-books.
School Hygiene (Shaw).
School Sanitation and Decoration (Burrage and Bailey).

Spring Term. — Sixth Grade

1. *Workers in the Soil.* (*a*) Ants; their social habits, nests, food, and burrowing.

(*b*) The earthworm. Its life history; structure and

organs. Darwin as a student of the earthworm. Value of the earthworm to agriculture and plant life.

(*c*) Burrowing animals: mole, ground hog.

References.

The Action of Earthworms in the Formation of Vegetable Mould (Darwin).

Worms and Crustacea (Hyatt).

Ants, Bees, and Wasps (Lubbock).

2. *The flower garden.* (*a*) The school flower garden. Transplanting wild flowers. The garden flowers: nasturtium, salvia, tulip, roses, honeysuckle, carnation, petunia.

(*b*) The home garden.

(*c*) Ferns and a fernery. Spores and modes of propagation. Mosses and lichens.

(*d*) Climbing vines. Ampelopsis or Virginia creeper. English ivy.

(*e*) Foliage plants.

(*f*) Insects damaging flower gardens. Plant lice. Treatment of plants.

References.

The Practical Garden Book (Bailey).

Garden Making, Suggestions for utilizing Home Grounds (Bailey).

3. *The ventilation of a house.* (*a*) The chimney and fireplace as a means of ventilation.

(*b*) Plans of ventilating the schoolhouse. Furnace ventilation. Ventilating fans. The circulation of fresh and foul air.

(*c*) The need of fresh air in a building. The lungs and breathing. Deep breathing. Ventilation of sleeping rooms. Effects of exercise upon breathing. Running, ball playing, gymnastics, etc.

(*d*) Danger of tight houses. Bad effects of poorly ventilated schoolhouses. The danger of drafts from windows and doors.

References.

School Sanitation and Decoration (Burrage and Bailey).
Handbook of Household Science (Youmans).

4. *Instruments and inventions.* (*a*) The lift-pump. Air pressure. Valves and mechanism of the pump. The force-pump.

(*b*) The microscope; its important uses.

(*c*) The siphon and its uses.

References.

Outlines of Physics (Nichols).
Physics for Grammar School (Harrington).
Elements of Physics (Rowland and Ames).
Other text-books in Physics.

5. *The atmosphere.* (*a*) The nature of the atmosphere. Its parts. Its constituent elements. Experiments.

(*b*) Extent and weight of the air.

(*c*) Relation of the atmosphere to heat and its absorption, to sound, to animal life; to man; to rain and moisture.

(*d*) The winds and their cause.

References.

The Ocean of Air (Giberne).
Text-books in Physics.

6. *The spring birds nesting about houses and barns.* (*a*) The swallow; nesting habits, insect eaters, catching insects on the wing.

(*b*) The chimney-swift and its home in chimneys. Its value as an insect destroyer.

(*c*) The house wren and other house-seeking birds. Wren houses.

(*d*) The bat; its peculiar structure, organs, and habits. Its service as an insect catcher. A mammal.

(*e*) How to encourage the birds to nest about the houses, lawns, etc.

References.

Birds, their Nests and Eggs (Ingersoll).
Birds and Bees (Burroughs).
Birds of the Eastern United States (Chapman).
Birds of Village and Field (Merriam).
Birds of the United States (Apgar).

Fall Term. — Seventh Grade

1. *The care and management of a grove or forest.* (*a*) Review of previous tree studies. Kinds of trees, leaves, bark. Seedlings. Leaf coloration. Light relations among trees.

(*b*) The renewal of forests from year to year. Natural seeding and growth of seedlings. Scattering of seeds by wind, birds, and animals. How man may help nature in planting seeds.

(*c*) How the forest trees are injured or destroyed. Wind and storms. Forest fires. Insects, as bark beetles and tussock moth. The value of ichneumon-flies to trees. Borers, leaf-crumplers. Injury of trees by rabbits, squirrels, sheep, and cattle. Mosses, lichens, and parasites. Forces of decay in the forest. Mould, insects, bacteria, moisture, and weather.

(*d*) The cultivation of a forest. Value of different trees. Length of time required for producing useful tre[illegible]f common kinds.

(*e*) Lands adapted to different kinds of forests. The profit of cultivating forests.

(*f*) The United States division of forestry. Its efforts to protect and encourage forestry in the United States.

References.

A First Book of Forestry (Roth).
Primer of Forestry (Pinchot).
Forestry for Farmers. Farmers' Bulletin, No. 67.
Our Native Trees (Keeler).
Trees of the United States (Apgar).

2. *Insect life in the pond.* Visits to the pond. (Review of earlier studies.) (*a*) Giant water beetle. Mode of moving, breathing, feeding, etc.

(*b*) Dragon-flies. Damsel flies. Study of their beautiful form and coloring.

(*c*) Caddis flies. Feeding upon plants. Changes and habits.

(*d*) An aquarium. Its construction and use in insect study.

(*e*) Life histories of these insects and their adaptation to environment.

References.

The Natural History of Aquatic Insects (Miall).
Life in an Aquarium. Cornell Teachers' Leaflets (Rogers) No. 11.
Life in Ponds and Streams (Furneaux).

3. *Butterflies and moths.* Review of earlier studies of cabbage butterfly, etc. (*a*) The milkweed butterfly. Life history. Metamorphosis, egg, larva, chrysalis, and butterfly. Its w[illegible] mouth organs, food, migrations. Collection and cor[illegible]of other butterflies.

(*b*) The moths. The cecropia and its life history, metamorphosis, etc. Nocturnal habits. The harmful moths in the household. How to prevent the ravages of moths in clothing.

References.

Insect Life (Comstock).
Butterflies (Scudder).
The Milkweed Butterfly (Scudder).
Moths and Butterflies (Ballard).

4. *Cyclonic storms.* (*a*) Highs and lows and the circulation of the air.

(*b*) The movement of a cyclonic storm in its general course. Predictions of storms.

(*c*) Use of weather maps showing the movement of cyclonic storms.

(*d*) National weather bureau. Signals and weather reports. Effects upon sailors, farmers, and railroads.

(*e*) The barometer. Its construction and use. The rain gauge.

References.

Elementary Meteorology (Waldo).
About the Weather (Harrington).

5. *Fire and the process of combustion.* Review of previous topics. Uses of fire. (*a*) Early modes of producing fire by friction. The old myths about fire. Prometheus.

(*b*) The light of a candle. Explanation. Parts of the flame.

(*c*) Oxygen and combustion. The wood fire. Experiments. Results of combustion.

(*d*) Things which are combustible, as wood, coal, oil, gas.

(*e*) Spontaneous combustion.

(*f*) Dangers from fire. Modes of prevention. Fire-proof construction. Asbestos.

(*g*) Sources of heat in the sun. How stored up in vegetation.

References.

How a Candle Burns. Cornell Teachers' Leaflets, No. 2. Text-books in physics.

6. *Value of various gymnastic exercises.* (*a*) Bodily measurements and tests. The value of expert trainers and instructors.

(*b*) Chief forms of useful exercise and their value.

(*c*) Value of moderate, systematic exercise at home, at school.

(*d*) Training to strengthen special organs. The lungs and chest. Building up of weak parts.

(*e*) A gymnasium. Uses of different apparatus.

(*f*) The ideal of a strong, healthy body.

(*g*) Ideas of different races in regard to physical education: Greeks, English, Germans.

(*h*) Influences in cities tending to physical deterioration.

(*i*) Historical illustrations of physical training and health experts.

References.

Our Bodies and How We Live (Blaisdell).
The Human Body (Newell).
Physiology and Hygiene (Hutchinson).

Winter Term. — Seventh Grade

1. *Distilled liquors.* (*a*) Whiskey and brandy. The bad effects of drunkenness. Tastes and habits formed by moderate drinking. Loss of self-control.

(*b*) Evil effects of distilled liquors on health and the nervous system.

(*c*) Testimony of physicians. Whiskey and brandy not now used so much by physicians.

(*d*) Railroads and insurance companies and their requirements. Danger of employing drinking men in places of responsibility.

References.

Graded Lessons in Hygiene (Krohn).
Applied Physiology (Overton).
Our Bodies and How We Live (Blaisdell).

2. *The kitchen and cooking.* (*a*) Bread-making. Review of previous studies. Whole wheat bread.

(*b*) The chemistry of bread-making. Yeast; its nature and effects. Bacteria.

(*c*) Baking-powder; good and bad. Baking-powder biscuit. Cream of tartar.

(*d*) Cake-making. Pastries, pies. Pastries too rich and not easily digested.

(*e*) Salads. Healthfulness and economy of salads. Kinds and preparation of salads. Oil.

(*f*) The dining room. Furnishing and decoration.

References.

Handbook of Domestic Science, Chapters VIII and X (Wilson).
Bread and Bread-making. Farmers' Bulletin, No. 112.
The Chemistry of Cookery (Williams).
Domestic Science in Elementary Schools (Wilson).

3. *Descriptions of remarkable vegetation.* (*a*) Forests of California. Selvas of Amazon. The bamboo. The banyan tree.

(*b*) Fruit-producing trees: cocoanut, banana, breadfruit, olive, fig, date, palm, etc.

(*c*) Desert vegetation in America, Asia, and Africa: cactus, prickly pear, eucalyptus.

(*d*) Plant and animal life in the sea.

References.

The Plant World (Vincent).
A Reader in Botany (Newell).
The Wonders of Plant Life (Herrick).

4. *The sick room.* Healthful conditions. (*a*) Fresh air and ventilation. Sunshine.

(*b*) Cleanliness and neatness. Keeping dust from furniture and floor.

(*c*) Bedding and clothing of patient.

(*d*) Cheerfulness, flowers, etc. Remove faded flowers and supply fresh water daily.

(*e*) Visitors and conversation.

(*f*) Trained nurses. The importance of intelligent nursing.

References.

Domestic Science in Elementary Schools (Wilson).
Our Bodies and How We Live (Blaisdell).

5. *The heart and circulation.* Review of earlier studies in physiology and animal life. (*a*) The heart and its structure, relation to veins and arteries. Nature of the blood.

(*b*) The arteries. The veins. The capillaries. The pulse and flow of the blood. Circulation in the frog's foot.

(*c*) Building up of tissues by the blood. Removal of waste.

(*d*) Relation of the blood to digestion and respiration. Mutual dependence of the vital organs upon one another.

(*e*) Effects of exercise upon heart action.

(*f*) The effect of alcoholic stimulants upon the heart.

References.

Lessons in Elementary Physiology (Huxley).
Physiology and Hygiene (Hutchinson).
The Human Body (Newell).
How to Keep Well (Blaisdell).

6. *Inventions and machines.* (*a*) Electric bells. The battery and the electric current.

(*b*) Electric telegraph and the system of telegraphy.

(*c*) History of the telegraph. The life of Morse.

(*d*) The Atlantic cable and the work of Field.

(*e*) Commercial changes produced by the use of the telegraph. Other effects upon newspapers and political life.

References.

Outlines of Physics, an Elementary Text-book for Secondary Schools (Nichols).

Other text-books in Physics: —

The Story of Electricity (Monro).
The Progress of Inventions in the Nineteenth Century (Byrn).

7. *Medicines.* Review of earlier topics. (*a*) Useful medicines. Common ones: quinine, Pond's extract, laxatives. External applications; treatment of wounds and accidental injuries.

(*b*) The prevention of disease; by proper diet, clothing, avoidance of exposure, and exercise.

(*c*) Patent medicines. Large amount of alcohol in many patent medicines.

(*d*) Poisons and antidotes and their occasional use. Danger to children.

(*e*) The advice of physicians needed before taking medicines.

(*f*) The folly of trusting quacks and nostrums.

References.

Our Bodies and How We Live (Blaisdell).
Text-books of Physiology.

Spring Term. — Seventh Grade

1. *Musical instruments.* (*a*) The tuning-fork. Vibrations and sound.

(*b*) The violin. The vibrations of a string. The manufacture of violins. The masters.

(*c*) The bell. Tones and overtones. Famous bells.

(*d*) The piano. The construction of a piano. Great musicians. The pipe-organ. The orchestra.

(*e*) The horn, drum, and other musical instruments.

(*f*) The human voice; vocal chords. The common musical scale.

(*g*) The various uses of music in theatres, churches, homes.

(*h*) The human ear. Its structure and adaptation to sound.

References.

Sound, a Series of Simple Experiments (Mayer).
Text-books on Physics and Physiology.

2. *The protection of garden plants, fruit trees, and shade trees from harmful insects.* (*a*) Review of apple and peach tree, codling moth and apple-tree borers, tent-caterpillar, cutworms. Insect eaters, as woodpeckers, chickadee, nuthatch, etc. Insect pests on the farm; chinch-bug; grasshoppers, etc.

(*b*) Life histories of the rose beetle, cankerworm, the apple maggot, apple-leaf crumpler, plant lice, the scale insects.

(*c*) Mildews and moulds on fruit trees and garden plants.

(*d*) Modes of destroying the various pests by protecting swallows, bats, woodpeckers, meadow-larks, and other insect eaters, also by the use of sprays and poisons.

(*e*) Spraying compounds and their value. Machines and contrivances for spraying.

References.

Nature Study and Life, Chapters XII and XIII (Hodge).
The Spraying of Plants (Lodeman).
Insects Injurious to Fruits (Saunders).
Injurious Insects of Farm and Garden (Treat).

3. *The earth and other planets.* (*a*) Review of earlier studies of the sun, moon, planets, and constellations.

(*b*) The earth and its path round the sun. The plane of the ecliptic. Corresponding paths of other planets. The series of planets and distance from the sun. Note planets visible evening or morning.

(*c*) The moon and its changes during four weeks. Its value as a light giver and its influence upon the tides. What is known about the moon and conditions upon its surface.

(*d*) Eclipses of sun and moon, and how produced.

(*e*) The sun as the centre of the solar system.

References.

The Story of the Earth (Seeley).
The Story of the Solar System (Chambers).
Starland (Ball).

4. *Bacteria.* (*a*) Modes of studying bacteria. Recent advances in study of bacteria. Value of microscope.

(*b*) Pasteur and his experiments. Fermentation. Wines.

(*c*) Useful bacteria and their important service in many ways.

(*d*) Bacteria and disease. Changes in medical treatment due to a study of bacteria.

(*e*) The lesson of cleanliness as taught by the study of bacteria.

References.

> The Story of Germ Life (Conn).
> Louis Pasteur: his Life and Labors (Hamilton).
> Popular Readings in Science (Gall and Robertson).

5. *The English sparrow.* (*a*) Importation to America and history of its conquest of America.

(*b*) Its good and bad qualities. Habits; relation to other birds; quarrelsomeness. Nesting habits, food, and relation to weed seeds and insect pests.

(*c*) Study of bird structure as typified by the English sparrow. Bony structure, feathers, bill, feet.

(*d*) Means of getting rid of the English sparrow.

References.

> Nature Study and Life (Hodge).
> Elementary Lessons in Zoölogy (Needham).
> The English Sparrow. Bulletin.

6. *Life history of the oak.* (*a*) Spring blossoms and leaves. The sprouting and growth of the acorn.

(*b*) Uses of the bark, roots, leaves, and stem in the growth of the tree. The flow of sap; work of the leaves and sunlight.

(*c*) The rings of growth as shown by a cross-section of

the trunk. Collect specimens and compare with the rings of growth in other trees.

(*d*) Insects which house in the bark and leaves of the oak. Gall nuts. Squirrels.

(*e*) The uses of the oak to man; lumber; bark; shade; mast.

(*f*) Long period of the oak's life. Famous historical specimens.

References.

Leaves and Acorns of our Common Oaks (Wyman). Cornell Teachers' Leaflets.

The Oak (Ward).

Fall Term. — Eighth Grade

1. *Classification of Trees.* (*a*) The hard wood forests. Review of chief groups.

(*b*) Evergreen forests.

(*c*) Tropical forests.

(*d*) Forest preservation.

(*e*) The Department of Forestry. Government preserves. Forest fires. Exploitation of forests by lumber companies.

2. *The rocks and rock strata.* Review of earlier studies. Rock decay; kinds, etc. (*a*) Collections of rocks to illustrate the chief classes of rocks, soil, sands, etc.

(*b*) Stratified rocks: how produced and the long history they suggest.

(*c*) Igneous rocks. Volcanic action and internal heat of the earth.

(*d*) Chief periods in geological history.

(*e*) Excursions to study local geological forms and history. Review of the ice age.

(*f*) Kinds of stone used for building purposes, for statuary, monuments, etc.

References.

Town Geology (Kingsley).
Outlines of Field Geology (Geike).
The Story of the Earth (Seeley).
First Book in Geology (Shaler).

3. *Game birds.* (*a*) Partridge. Its habits and life history. Its protective coloring. Its flight.

(*b*) Prairie chicken. Its home in the grain fields.

(*c*) The wild pigeon. The great flocks once seen.

(*d*) Game laws and protection of game. Nesting seasons. The danger of exterminating our game birds.

References.

Protection of Birds and Game (Directory of State Officials and Organizations for 1901, Circular No. 33, United States Department of Agriculture).
Information concerning Game, Seasons, Shipment, and Sale (Circular No. 31, United States Department of Agriculture, 1900).
Citizen Bird (Wright and Coues). The Macmillan Co. Interesting and well illustrated.

4. *The essentials of a good dwelling house, as based upon scientific knowledge.* (*a*) Healthful location, with healthful surroundings. Materials best suited for sanitary construction.

(*b*) Dry, clean cellar. Cemented floors and walls. A coal, fruit, and vegetable cellar.

(*c*) Plumbing and sewer connections. Soil pipe. Bathroom. Laundry.

(*d*) Kitchen equipment: sink, pantry, refrigerator, cooking outfit, laundry.

(*e*) Ventilation by flues and circulation of fresh air.

(*f*) Safe construction against fire. Flues, tile lined. Furnaces, or heating plant.

(*g*) Pure water. The sources. Kind of pipes. Filters, cisterns, wells, etc.

(*h*) Gas and electric lights. Piping and wiring. Danger from gas and electric wiring.

(*i*) Cleanliness by means of soap, disinfectants, sunlight. Proper neatness and care in sick room.

(*j*) Electric bells, telephones, and wiring.

(*k*) Library. Standard books in history, science, and literature.

(*l*) House decoration: paper, frescos, pictures, and fine art.

(*m*) Locks. Safe; for safety deposit, for business papers, silver, jewels. Vaults in banks.

(*n*) Flower garden and conservatory.

(*o*) Piano and musical instruments.

(*p*) A workshop with tools.

References.

Domestic Science in Elementary Schools (Wilson).
School Sanitation and Decoration (Burrage and Bailey).

6. *Interesting inventions in printing.* (*a*) A rotary steam printing press. The speed and quantity of work done. Labor saving.

(*b*) The linotype machine. The effect of this machine on printing and labor.

(*c*) Electroplating. An application of chemistry and electricity.

(*d*) Historical development of printing. Gutenberg. Franklin. Later inventors.

References.

Progress of Invention in the Nineteenth Century (Byrn).

The Wonders of Modern Mechanism (Cochrane).

7. *Alcoholism and opium.* (*a*) Review of previous studies of alcoholic drinks.

(*b*) Evil effects of the liquor traffic upon homes and upon society. Amount of crime caused by drunkenness. Great waste of money in the sale and use of alcoholic drinks.

(*c*) The important and legitimate uses of alcohol.

(*d*) Opium, the sources of opium. Its use and demoralizing effects.

(*e*) The relation of the government to the manufacture and sale of alcoholic drinks and narcotics.

References.

Graded Lessons in Hygiene (Krohn).

Applied Physiology (Overton).

Our Bodies and How We Live (Blaisdell).

Winter Term. — Eighth Grade

1. *Respiration.* Review and general survey of the vital organs. (*a*) The lungs and their structure and function. Breathing in lower animals and in man.

(*b*) Relation of lungs to circulation of blood. Purification of the blood in the lungs.

(*c*) Causes of weak lungs. Fresh air and deep breathing. Increase of lung capacity. Exercise and its effects.

(*d*) Lung diseases and their prevention.

(*e*) Consumption as a germ disease and modes of preventing its spread. Modes of isolating it. Pneumonia.

(*f*) The stethoscope.

(*g*) Influence of climate on lung trouble.

References.

Our Bodies and How We live (Blaisdell).

The Human Body (Newell).

2. *Scientific cleanliness in surgery.* Review of sick room. (*a*) The operating room and its equipment.

(*b*) Bacteria and their danger, and provision against them. The instruments, bandages, sterilizing, hands, and cloths.

(*c*) Antiseptics and disinfectants and their use by surgeons and nurses.

(*d*) Anæsthetics and their value in surgery. Great improvement in modern surgery.

(*e*) Results of scientific care, cleanliness, and scientific skill in dealing with surgical cases.

(*f*) Suggestions as to care in accidental cuts, wounds, and sores. Blood poisoning.

(*g*) Great importance of hospitals and their work.

3. *The brain and nervous system.* The brain the seat of control and of intelligence. (*a*) The brain and its structure. Its protection by the cranium.

(*b*) Afferent and efferent nerves and their different uses.

(*c*) Control of the body through the nerves.

(*d*) Derangement of the nervous system.

(*e*) Effects of alcoholic drinks on the nerves and brain.

(*f*) General conditions of a healthy body.

References.

Applied Physiology (Overton).

Lessons in Elementary Physiology (Huxley).

4. *The electric light.* (*a*) The battery and the electric current.

(*b*) The light; how produced.

(*c*) Edison and his experiments.

References.

The Story of Electricity (Monro). D. Appleton & Co.
Elements of Physics (Rowland and Ames).
Lessons in Electricity (Tyndall). D. Appleton & Co.
Other text-books of Physics.

5. *Scientific modes of extracting and using the metals.* (*a*) Assaying and its value in mining operations.

(*b*) Smelting of ores. The uses of quicksilver. The reduction of low-grade ores.

(*c*) The blast furnace and the production of pig-iron.

(*d*) Steel production. The Bessemer process. The various uses of steel.

(*e*) Aluminum. Its production and use.

References.

Experimental Science (Hopkins).
The Chemistry of Common Life (Johnston).

6. *A vestibuled train, a product of scientific invention.* A varied application of science to life. (*a*) A house with heating, lighting, ventilation.

(*b*) Kitchen and cooking. Dining car.

(*c*) Sleeping rooms. Smoking rooms. Lavatories.

(*d*) Danger of wrecks.

(*e*) Steam brakes. Automatic coupling. Economy and life-saving devices.

(*f*) Steam-engine. Mode of applying power in a locomotive engine.

(*g*) Car building, architecture, and decoration.

(*h*) The engineer; his responsibility. His control of the train. The necessity for skill and watchfulness.

References.

The Wonders of Modern Mechanism (Cochrane).

7. *The adulteration of foods.* Review of previous study of foods and drinks. (*a*) Modes of food adulteration, as in the case of butter, flour, sugar, oil, canned fruits, wines, whiskeys, milk, candies, coffee. Tests of food adulteration.

(*b*) The profit from food adulteration and the extent of it.

(*c*) Necessity for government inspection and strict laws. Inspection of meats to prevent the sale of diseased meats, scientific knowledge needed.

(*d*) Modes of food preservation. Canning, drying, cold storage, refrigerator cars and ships. The refrigerator in houses. Value of ice. Dangers.

References.

The Care of Milk. Farmers' Bulletin, No. 63.
Sugar as Food. Farmers' Bulletin, No. 93.
Domestic Science in Elementary Schools (Wilson).
Municipal Engineering and Sanitation (Baker).

Spring Term. — Eighth Grade

1. *The hothouse and its equipment.* (*a*) The exotics in a hothouse. Adaptation to warm climate. Heating.

(*b*) The flora of the tropics as reproduced in the hothouses.

(*c*) The flora of desert and arid regions. Cacti, century plant.

(*d*) Excursions to hothouses to study modes of treating hothouse plants.

(*e*) Diseases of plants in hothouses. Bees in hothouses for cross-fertilization.

(*f*) The propagation of plants in a hothouse.

References.

The Practical Garden Book (Bailey).

2. *The warblers.* The myrtle, summer, palm, Blackburnian, black and white creeping, black throated blue.

(*a*) Place of warblers among the families of perching birds. Elementary classification of birds.

(*b*) The food of the warblers.

(*c*) The food of other birds. Study of birds' stomachs to determine their food.

(*d*) Experiments and reports of the government. Useful and hurtful birds to farmers, fruit-growers, etc.

(*e*) False conclusions reached by gardeners, farmers, and fruit-growers in regard to the good and harm done by birds. Necessity for science.

References.

Nature Study and Life (Hodge).
First Book of Birds (Miller).
Animal Memoirs, Part II, "Birds," (Lockwood).
Birds of the Village and Field (Merriam).

3. *Landscape gardening.* Review of earlier tree and flower study. (*a*) Suitable trees, bushes, foliage plants, and flowers for planting on lawns.

(*b*) Plan of laying out lawns, parks, and gardens. Color effects. Useful trees and plants in forest, field, and nursery.

(*c*) Best season for planting trees, bushes. Review of nursery and tree planting.

(*d*) Visits to well-kept lawns and parks to observe plans and effects.

References.

Garden Making, Suggestions for utilizing Home Grounds (Bailey).

4. *Fossils in the rocks.* Review of rocks and rock strata. (*a*) Collection of fossils. Phosphates in the soil and their value.

(*b*) The history of extinct animal life.

(*c*) Coral reefs and their history.

(*d*) The geological survey. Its history. Relation of geological survey to agriculture and mining.

(*e*) Visits to museums where fossil remains and casts are seen.

(*f*) Famous discoveries of fossil remains.

References.

First Book in Geology (Shaler).
The Earth and its Story (Heilprin).

5. *The kitchen and cooking.* Review of earlier lessons on foods and cooking. (*a*) The preparation, use, and cooking of fruits. The preservation of fruits.

(*b*) The analysis of the food stuff in vegetables, fruits, and meats.

(*c*) The essentials of a healthful diet. Common faults of cooking and dieting.

(*d*) The value of science in determining the value of foods and methods of cooking.

References.

Domestic Science in Elementary Schools (Wilson).
Handbook of Household Science (Youmans).

6. *Photography.* (*a*) History of photography.

(*b*) The camera; its construction and use. Materials and processes of photography.

(*c*) Importance of photography in practical life and in science.

References.

Photography, Indoors and Out (Black). Houghton, Mifflin & Co.

The Story of Photography (A. T. Story).

CHAPTER X

BOOKS AS AN AID TO SCIENCE TEACHING

Perhaps the chief difficulty in the way of good science work in the grades is the poverty of science knowledge on the part of teachers. It is not a fault with which teachers are to be upbraided so much as a natural result of our usual course of study in the past. Even what science knowledge teachers have acquired in high schools and other advanced courses of study is not only inadequate, but often unsuitable to the instruction of children. In all the higher schools there is, or has been, a strong tendency to system, classification, and morphology, and not sufficient detailed study of particular forms and life histories, such as arouse the interest and observation of children. The usual text-books in natural science are extremely inadequate to prepare teachers for the instruction of children. They do not contain the right sort of material to serve as topics in the grades, even if the work is experimental or in field excursions.

Books of science are very important in the training and preparation of teachers for their work in classes. They do not take the place of personal observation, experiment, excursion, use of instruments, collections, in short, direct contact with nature in a multitude of ways; but books are a great help to teachers both in the knowledge offered and in guiding their observations and in suggesting important centres and ways of observation. From books the teachers

get direct stimulus and suggestion where to look and what to look for, and then they have sufficient start in the right direction to be left to their own resources.

The different books helpful to teachers may be classified as follows: —

1. Text-books and books of classified scientific knowledge. Through his previous studies these books are familiar to the teacher, and serve as a basis for his own systematic grasp of the subject. They are an excellent general guide and reference, and furnish that large survey of the whole field which enables him to keep his bearings.

A short list of identification books, which are useful to teachers and pupils determining and classifying new specimens, is grouped with the text-books.

2. Perhaps the most helpful books to teachers are the monographs on particular topics. They alone make it possible for the teacher to equip himself thoroughly for the teaching of particular topics.

It is this kind of detailed information which may stimulate the teacher to the most careful observations on his own part, and furnish him with a rich fund of accurate scientific knowledge. With children especially, this fulness of concrete detail is indispensable to insight and interest. It is exceedingly desirable that good, cheap monographs be multiplied upon all the important topics of natural science, and then teachers will be able in large measure to help themselves. They do not take the place of observation, but greatly assist it.

3. Works of a higher literary character, as the writings of Burroughs and Thoreau, stimulate a love for nature and at the same time suggest the closest methods of observation. The classic form of some of these writers adds much to the charm of their studies. It need not be supposed

that the classic form is a substitute for the scientific spirit, but it is a good channel through which the scientific spirit may flow. We have a number of delightful books which breathe the spirit of a kindly sympathy for bird, insect, and even plant.

These books are good companions for those who wish to study nature in the open air. They are especially valuable for the moral and æsthetic attitude of mind that they cultivate, for the humanizing and protecting gentleness with which they observe animal and plant life. This counteracts the naturally thoughtless, wasteful, and destructive habits of children. The tree or a flowering plant has a life not to be wantonly destroyed. The robins and sparrows have anxieties and rights which the schoolboy should respect. The æsthetic sense, the appreciation of delicacy and beauty of form and color and motion in the things of nature, the whole æsthetic taste and appreciation, are matters of slow development, and some of the classic writers just mentioned are well able to open our eyes to these best influences of nature study.

A few of the masterpieces of scientific literature are grouped with the above.

By means of the masterpieces we are able to keep abreast of scientific thought. The schoolmaster must not fall far behind the more recent developments of scientific knowledge. Otherwise he will be teaching what scientists regard as exploded theories. Moreover, the great writers like Darwin, Agassiz, Gray, Tyndall, Haeckel, Lyell, and their like, are the most stimulating and broad-minded in their influence. It is of very great advantage to come in contact with the masters of any science.

4. Books of practical application of science to life.

These are extremely useful books for teachers in working

up special topics for the schoolroom. Many of them are monographs with full and practical information designed for farmers, gardeners, cooks, foresters, nursery men, and other specialists.

Descriptions of machines, inventions, and industrial processes are also included. The government reports, Farmers' Bulletins, and state publications are in cheap pamphlet form and can be had on application or for a small price. Full sets of these publications should be supplied to schools as reference material.

5. Nature study books for the collateral reading of children.

In the last few years a large number of science readers for use in the grades for supplementary reading has been offered to the schools by different publishers.

It is a serious question to determine just what is the value of these science readers. It should first of all be clearly understood that they do not take the place of observation and real nature study. They should follow rather than precede the oral lessons, excursions, collections, and class study. After children have been introduced by observation and class instruction to important topics, it may prove valuable to use the supplementary readers to enlarge and define more closely their scientific knowledge. Science readers, however, are to be regarded as books of instruction for purely supplementary and private reading, rather than as text-books for regular reading exercises. The regular reading lessons should be devoted to the appreciative study and rendering of American and English classics. Books of information, whether from science, history, or geography, are not good enough to serve for the purpose of the standard reading exercises. Many of the science readers, however, will prove quite helpful to teachers in supplying them with a part, at

least, of the necessary scientific knowledge. Larger, more complete scientific treatises are, of course, better; but most teachers have neither the time nor the money to spend upon the larger, complete books of science.

6. Elementary popular science books for older readers. A number of excellent books are found in this group for older children and for the broader information of teachers.

Many of these books might deserve to be placed with the literary works and masterpieces of science. They should be well represented in the school library, and used for reference and for stimulation along many lines of investigation.

7. The list of biographies of eminent scientists may prove of much value to teachers and older pupils.

It is advisable to use them in connection with the topics which they best illustrate.

They are a means of awakening an interest in the history of scientific progress, which they illuminate. The problems and difficulties of science are shown up more clearly in the labors of such men than by any other means. Such biographies should be of great service to children, both in their personal influence and in their scientific bearings.

8. Books of professional and pedagogical value to teachers. These books discuss courses of study, methods of instruction, and give many excellent illustrations of the treatment of topics. On account of the rapid development and great importance of nature study in schools, the professional literature is growing rapidly in quantity and value.

Some of these books, like Hodge's "Nature Study and Life," are surprisingly helpful to teachers.

1. TEXT-BOOKS

How Plants Grow (Asa Gray). American Book Co. pp. 233.
Plant Relations (John M. Coulter). D. Appleton & Co. pp. 264.
The Nature and Work of Plants (Daniel T. McDougal). The Macmillan Co.
Lessons with Plants (L. H. Bailey). The Macmillan Co. pp. 491.
Lessons in Botany (Asa Gray). American Book Co. pp. 226. For beginners.
Botany All the Year Round, a practical text-book for schools (E. F. Andrews). American Book Co. pp. 302.
The Teaching Botanist (William F. Ganong). The Macmillan Co. pp. 270. Outline and directions for an elementary course.
Laboratory Practice for Beginners in Botany (William A. Setchell). The Macmillan Co. pp. 199.
Animal Activities (Nathaniel S. French). A first book in zoölogy for high school. Longmans, Green & Co. pp. 262.
Foundations of Botany (Bergen). Ginn & Co.
Plant Dissection (Arthur Barnes & Coulter). Henry Holt & Co. pp. 250.
Practical Biology (Huxley & Martin). The Macmillan Co. pp. 498.
First Lessons in Physical Science for Grammar Schools (Avery-Sinnott). Butler, Sheldon & Co. pp. 160.
Appleton's Physics. American Book Co.
Physics for Grammar School (Charles L. Harrington). American Book Co. pp. 123. A series of experiments.
Easy Experiments in Physical Science (Leroy C. Cooley). American Book Co. pp. 85.

Elements of Physics (Rowland & Ames). American Book Co.
A Compend of Geology (Joseph LeConte). American Book Co. pp. 426.
Elementary Chemistry (Clarke & Dennis). American Book Co. pp. 340.
Elements of Chemistry (R. P. Williams). Ginn & Co. pp. 412.
Physical Laboratory. Manual for secondary schools (S. Coleman). American Book Co. pp. 234.
Lessons in Physics (Lothrop D. Higgens). Ginn & Co. pp. 379.
Practical Zoölogy (Buell P. Colton). Ginn & Co.
Animal Studies (Jordan, Kellogg & Heath). D. Appleton & Co.
Zoölogy (Colton). 2 vols. D. C. Heath & Co.
Elementary Meteorology (Frank Waldo). American Book Co. pp. 373.
Easy Star Lessons (Richard A. Procter). Arranged by months. G. P. Putnam's Sons. pp. 229.
Elements of Astronomy (Sir Robert Ball). The Macmillan Co. pp. 183.
Outlines of Field Geology (Sir Archibald Geikie).
Outlines of Physics. An elementary text-book for secondary schools (Edward L. Nichols). The Macmillan Co. pp. 452.
Anatomy (Gray). Lea Brothers.
Physiology for Beginners (Foster & Shore). The Macmillan Co. pp. 241.
Text-book of Anatomy (Gerrish). Lea Brothers.
Our Bodies and How We Live (Albert F. Blaisdell). Ginn & Co. pp. 412.
The Human Body (H. Newell). Henry Holt & Co. pp. 337.

Applied Physiology (Frank Overton). American Book Co. pp. 432.

Physiology (Colton). D. C. Heath & Co.

Lessons in Elementary Physiology (Thomas Huxley). The Macmillan Co. pp. 577.

Graded Lessons in Hygiene (William O. Krohn). D. Appleton & Co.

How to Keep Well (Albert F. Blaisdell). Ginn & Co. pp. 250.

Physiology and Hygiene (Joseph C. Hutchinson). Maynard, Merrill & Co.

Identification Books

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